UNIVERSITÉ DU QUÉBEC À MONTRÉAL

ESSAIS EN THÉORIE DU FURETAGE

THÈSE

PRÉSENTÉE

COMME EXIGENCE PARTIELLE

DU DOCTORAT EN ÉCONOMIQUE

PAR

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JUIN 2011

Remerciements

Cette thèse n'aurait pas pu être réalisée sans l'aide de mon directeur Alain Delacroix. Son expérience a eu une grande influence sur mes intérêts de recherche. Je tiens à le remercier pour sa grande disponibilité et son solide soutien tout au long de ces études. Merci particulièrement à Étienne Wasmer pour son introduction de la théorie du furetage ainsi que pour son encadrement lors de ses séjours à l'UQAM. Dans le cadre d'évaluation de cette thèse, Steven Ambler, Alain Delacroix, Markus Poschke et Étienne Wasmer ont fourni de nombreux précieux commentaires et suggestions.

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RÉSUMÉ

Cette thèse utilise la théorie du furetage afin d'étudier les problèmes reliés au marché du travail aux pays développés et en voie de développement.

Le premier chapitre contribue à la littérature récente sur les fluctuations du chômage à travers l'élaboration d'un modèle de concurrence monopolistique. Pour la raison que la procyclicalité de l'entrée des firmes implique la contracyclicalité de la marge de profit, suite à un choc positif de la productivité du travail, l'augmentation du profit des firmes existantes attirent l'entrée des nouvelles firmes. En entrant, ces dernières créent de nouveaux postes de vacance. Les firmes monopolistiques existantes font face à la nouvelle compétition y répondent en limitant moins leur output. Ces deux effets qui entraînent plus de postes vacants constituent un mécanisme d'amplification effectif pour rapprocher le modèle aux données. À travers les différentes stratégies de calibration pour tester la sensibilité des résultats, nous constatons que le modèle peut expliquer près de 50% de la volatilité trouvée dans les données.

Le second chapitre se concentre sur les effets du système d'enregistrement des ménages (Hukou) en Chine sur son marché du travail. Dans un contexte d'hétérogénéité des travailleurs, si le gouvernement chinois relâche cette loi (soit en permettant plus de résidents ruraux à vivre dans un lieu urbain ou soit en ne forçant pas les non-résidents de fournir leur statut Hukou), le taux de chômage diminuerait et plus particulièrement le bien-être social s'accroîtrait.

Le troisième chapitre expliquerait en quoi des travailleurs ayant les mêmes caractéristiques sont rémunérés différemment. Le mécanisme se veut de l'information asymétrique appliquée sur les firmes et travailleurs, et la négociation de type offre à prendre ou à laisser. Ceci avec le risque de séparation impliquent les firmes à productivité élevée s'engagent à offrir des salaires généreux. Quant aux travailleurs à faible productivité, ils ne demandent que des salaires modestes. C'est un mécanisme qui disperse la distribution des salaires. Les résultats numériques montrent que la dispersion salariale générée par le modèle réconcilie avec celle trouvée dans les données.

Mots clés : théorie du furetage, fluctuations du chômage, politique du marché du travail, dispersion salariale.

ABSTRACT

This thesis uses the search and matching theory to study the labor market. It has three chapters covering the following topics: the cycle behaviour of unemployment and vacancy; effects of labor market policy in developing countries; and wage dispersion among workers having similar characteristics.

The first chapter contributes to solutions available in recent literature on the unemployment volatility puzzle through developing a very simple monopolistic competition model. The key element that helps us to get more volatility in labor market variables is procyclical entry of firms that produces countercyclical markups. Following a positive productivity shock, vacancies increase and unemployment falls not just because of the entry of new firms, but also because existing firms restrict their output less and hire more since they are now face competition from more firm. Under plausible parameterizations, our model simulations can reach up to 50% of volatility of labor market key variables found in the data.

The second studies the effects of Chinese Hukou system of household registration (the law that limits migration the rural to the urban areas and vice-versa) on labor market outcomes. We find that if the Hukou system of household registration is relaxed by either decreasing the law enforcement or allowing more people to live in the city, urban unemployment rate would be reduced. More relaxed laws would help the urban sector become more attractive to rural residents, so firms hiring both illegal and legal Hukou status would benefit more from illegal worker since the rent firms extract from illegal workers is higher than that from legal workers and this in turn would induce firms to create more vacant positions.

The third chapter proves that within a two-side asymmetric information environment, the take-it-or-leave-it offer mechanism can effectively explain why worker having similar characteristics are paid differently. The reason is through possessing private information, both firms and workers will make only modest wage offers to avoid separation, a mechanism that disperses the wage distribution.

Key words: search and matching theory; unemployment volatility; labor market policy in developing countries; wage dispersion.

INTRODUCTION

One of the theories that could help explain successfully the labor market function is the standard Mortensen and Pissarides (1994) search and matching model. Since it was introduced, it has been widely employed in modern labor economics thanks to its tractability and rich implications. The aim of this thesis is to apply the standard model in explaining some of the labor market issues related to both developed and developing countries. Our studies cover only two countries: the United-States and China.

In the first chapter, we address the inability of the standard model to match fluctuations in labor market data. Despite the success of the model in terms of labor market policy applied in the most developed countries, it does however, under plausible parameter, fail to reach empirical labor market volatility levels, known as the unemployment volatility puzzle (Shimer (2005a)). Numerous works have attempted to solve this puzzle, and a great deal of progress has been made.

We explore a different mechanism through the development of a very simple model of monopolistic competition à la Dixit-Stiglitz developed by Ebell and Haefke (2009). The originality is the adaptation of competition to all sectors where each sector has a certain number of competing firms that respect the free entry condition. The extended model allows the markups to be variable instead of constant as in the Dixit-Stiglitz model. The intuition of why adding monopolistic competition could help amplifying the unemployment volatility is that monopolistic firms charge a price that is higher than their marginal cost by an amount equal to the markups. These latter are a decreasing function of the endogenous number of competing firms in the goods sector. In other words, a procyclical number of active firms is associated with countercyclical markups. Thus, following a positive productivity shock, vacancies increase and unemployment falls not just because of the entry of new firms, but also because existing firms restrict their output less and hire more since they are now face competition from more firms.

The fact that little has been done to explore the standard model in developing countries context, especially in China, motivates the study exposed in Chapter 2. The purpose of this chapter is to provide some policy recommendations to the Chinese government in facing the present challenges in the country's urban labor market. In particular, the policy of controlling migration between the rural and urban sectors, known as the hukou system of household registration, has been made of criticism by many prominent scholars. On the against-side, it has been proved to be responsible in rising social inequality and discriminating against migrant workers. On the for-side, it has helped in reducing pressures on urban labor market. Regarding whether or not the system should be abolished still remains a greatest challenge faced by the Chinese government, although many reforms have been made since 1980s and 1990s. Our study makes a contribution to the main literature on Chinese labor market policy by developing a standard search equilibrium model in rural-urban migration context as in Laing et al. (2005). We focus on the effects of relaxing the Hukow law on the urban labor market outcomes. The originality of our model is it allows workers be different in terms of productivity. Worker heterogeneity in our model can be thought of as not all workers would like to live in the countryside and not all workers would be qualified for urban sector jobs.

We find that if the Hukou system of household registration is relaxed by either decreasing the law enforcement or allowing more people to live in the city, urban unemployment rate would be reduced and the social welfare would be improved.

In the face of quick economic and social change in China, it is likely that the Hukou system will not be maintained in the future and there is a greater likelihood that workers prefer to work in the urban sector where more job opportunities with higher income, as compared to the rural sector.

The last chapter tries to answer the question addressed in wage inequality literature: Why are similar workers paid differently? In fact, empirical research has shown that observable worker characteristics such as education, experience, age, etc can only explain up to 30 percent of the wage variation. The remaining unobservable (unexplained) accounts for 70 percent and is often referred to the residual wage dispersion. The question has attracted numerous theorists to provide a convincing theory of wage dispersion. Search theory offers two candidate wage determination models that can explain the observed dispersion. The first is a model in which each employer chooses a wage policy in imperfect Bertrand competition with other employers. The second is a bilateral Nash bargaining model. In both models, incomplete information about the wages offered by the heterogeneous firms becomes the source of wage differences. Nevertheless, a recent quantitative assessment done by Hornstein et al. (2007) has shown that the wage dispersion levels predicted by search models are far from that found in the data.

We then modify an asymmetric information model introduced by Delacroix and Wasmer (2006) to address whether this kind of model can explain the dispersion of wage among similar workers. Our study is inspired by productivity dispersion among firms and utility dispersion among workers. Intuitively, if worker's utility from employment is high enough then he may want to lower his reservation wage. Similarly, more productive employers tend to offer generous wage offers than less productive ones. We find that under plausible parameter, asymmetric information along with take-it-or-leave-it bilateral bargaining mechanism can reach closely the amount of wage dispersion found in the Current Population Survey.

CHAPTER I

MONOPOLISTIC COMPETITION AND UNEMPLOYMENT FLUCTUATIONS

In this paper, we contribute to solutions available in recent literature on the unemployment volatility puzzle through developing a very simple monopolistic competition model. The key element that helps us to get more volatility in labor market variables is procyclical entry of firms that produces countercyclical markups. Following a positive productivity shock, vacancies increase and unemployment falls not just because of the entry of new firms, but also because existing firms restrict their output less and hire more since they are now face competition from more firm. Under plausible parameterizations, our model simulations can reach up to 50% of volatility of labor market key variables found in the data.

Keywords: labor market volatility, endogenous competition, countercyclical markups

1.1 Introduction

Unemployment fluctuations deserve intense study not only because they are associated with human capital depreciation but also because of the related productive and social externalities. The standard matching model presented by Mortensen and Pissarides (1994) (hereafter MP model) represents one of the main theories used to study the labor market, even though it fails to reach empirical labor market volatility levels, known as the unemployment volatility puzzle. The macro/labor literature has for some time tried to explain the fact with limited success. There are essentially two strands of explanations: rigid wage (as recently pursued by Shimer (2005a) and Hall (2005)) or small match surplus (see Hagedorn and Manovskii (2008)). On the one hand if wage is rigid, a positive labor productivity shocks will make output increase more proportionally than production cost and hence, more vacancies arise. On the other hand if the surplus in matches is small, small shocks suffice for dissolving many matches, implying large unemployment fluctuations.

In this paper, we present a different approach in which monopolistic competition among active firms can enhance significant labor market volatility. The key element that helps us to get more volatility in labor market variables is procyclical entry of firms that produces countercyclical markups. The model developed in this paper is based on the works by Ebell and Haefke (2009) and Delacroix (2006), yet it differs in the following characteristics. The focus is on the cyclical behavior of the labor market variables while these two papers study the effect of policies on the steady-state labor market outcomes. Specifically, the first paper studies how the Carter-Reagan deregulation in the early 1980s affect the US labor market and shows that barriers preventing a new firm from entering the market lead to a long-run decline in industry size equilibrium, and thus a decline in the degree of competition. In the long run, the effect on unemployment equilibrium is modest and the real wage significantly decreases. The second paper applies the Ebell-Haefke framework but especially focuses on the impact of monopolistic competition on unionized sectors and on non-unionized sectors. As such the author studies the interactions between unions and unemployment insurance, and his results are consistent with the unemployment benefit in Europe, which are more generous when compared to those in the US, yet also characterized by more extensive unionization and lower payroll taxes. Our work was designed for a different purpose: that of solving the unemployment volatility puzzle. Moreover, while the two original papers only focus on the effects that policies have on the steady-state outcome of the labor market, our study allows aggregate shocks to be stochastic. The model is augmented in a dynamic form to allow for the aggregate productivity shocks that follow a stochastic process.

The mechanism through which monopolistic competition helps to increase labor market volatility reveals that firms having monopoly power charge a price that is higher than their marginal cost by an amount equal to the markups. These latter are a decreasing function of the endogenous number of competing firms in the goods sector. In other words, a procyclical number of active firms is associated with countercyclical markups. Thus, following a positive productivity shock, vacancies increase and unemployment falls not just because of the entry of new firms, but also because existing firms restrict their output less and hire more since they are now face competition from more firm.

Some studies found in the literature that generate higher labor market volatility have been subject to criticism regard model parametrization such as the value of unemployment benefits employed by Hagedorn and Manovskii (2008) in order to attain small firm surplus. This value, including leisure utility, amounts up to 95% of per capita output. Thus, not just only it seems to be implausibly high but also it causes, according to Costain and Reiter (2007), unemployment responds unrealistically high to even a small productivity shock. In our framework however, we try to calibrate the model parameters to match the available data. One of the key parameters in our model, the worker bargaining power, is set to be low to pin down the wage share. In the literature, model generated wage share is usually high and close to output due to the worker bargaining power is set to satisfy the Hosios efficient condition.

Through assigning a plausible set of parameters, we find that the model reaches nearly 50% of volatility in the labor market key variables found in the data. Evaluating the model in other dimensions such as the cyclicality of entry and markups also demonstrates that the model performs quite well.

In the remainder of this paper, Section 1.2 briefly discuss the related literature. Section 1.3 describes the model and present the analytical results. Numerical exercises are performed in Section 1.4 and finally, Section 1.5 concludes.

1.2 Related literature

There has been numerous studies attempting to solve the unemployment volatility puzzle and a great deal of progress has been made. Shimer (2005a) initiates the debate by simulating a version of this model, finding that unemployment and vacancies are as volatile as labor productivity, even though the aggregate data reveals that they are much more volatile - by a factor of 20. He points out that the Nash bargaining solution used to determine wage is responsible for this. In the model, wage is negotiated according to the rule for surplus sharing, whereby an increase in labor productivity will increase wage by the same proportion. As such, firms' profits will remain unchanged over the business cycle, meaning they have little incentive to create jobs and thus the model exhibits a moderate level of labor market volatility. Shimer (2004) and Hall (2005) share the idea that to improve volatility in the labor market a sticky wage model is needed. Shimer in fact examines a constant wage model while Hall proposes a fixed bargaining wage set, and both conclude that a sticky wage model may result in substantial volatility. In the real world however a constant wage is implausible, yet the source of the bargaining set is still an unanswered question. They thus suggest that future research should focus on building a rigid wage model, and that a richer model would feature either wages affect worker turnover rates or asymmetric information formats. Certain studies attempt to endogenize wage rigidity by applying asymmetric information to match-specific productivity, and two of them, namely Guerrieri (2007) and Brügemann and Moscarini (2008), find tiny fluctuations in labor market variables. Guerrieri (2007) investigates a competitive search model (wage posting and not negotiating) both under full and private information in which she finds tiny fluctuations in labor market variables. The reason why she finds asymmetric information could dampen job creation in response to change in productivity is because of the firm's incentive to reveal worker's private effort by paying additional rents. More specifically, if a good shock hits a match relationship, firm's surplus increases but the rents that need to be paid to the workers become higher and thus overall, firm's profit may increase but not significantly for more job creation. In the similar framework, Brügemann and Moscarini (2008) prove that asymmetric information can only generate rent rigidity but not wage rigidity, yielding insufficient unemployment volatility.

The small match surplus approach was proposed by Hagedorn and Manovskii (2008), whereby the solution would be to have a high unemployment income representing 95% of per capita output. This strategy typically induces small profits left for firms and guarantees that their net payoff would be more responsive to small changes in productivity, thus resulting in higher job creation rates. The

Hagedorn and Manovskii (2008) calibration has been however subject to a great deal of criticism because, as demonstrated by Costain and Reiter (2007), significant increases in aggregate productivity would cause unrealistic fluctuations in unemployment rate. Moreover, obtaining adequate measures of non-market value is a difficult task in itself.

Other works attempt to make profit size small, such as that by Mortensen and Nagypal (2007) for example who include turnover costs, or Elsby and Michaels (2008), who introduce downward-sloped labor demand. Compared to the models in these papers, the one we developed has some specific and important distinguishing features. First, both papers only analyze the steady-state comparative statics. Although obtaining similar steady-state analysis is possible, the dynamic behavior might be quite different. Obviously including turnover costs (the costs of training and hiring workers) would be another way of guaranteeing small profit size. Silva and Toledo (2008) who report evidence on turnover costs and simulate the Mortensen-Nagypal model, and thus are able to attain up to one fourth of the volatility observed in labor market tightness. Downward-sloped labor demand means that output is a concave function of labor input, yet when firms demand more labor, the marginal return of labor decreases, resulting in a small marginal surplus for a match. Elsby and Michaels (2008) reach one third of the cyclical variation in labor market tightness.[1]

[1]Elsby and Michaels (2008) in fact obtains the full cyclical variation in the job finding rate but this latter is a direct function of the tightness generated from the matching function, resulting in virtually the same cyclical variation in both variables. The elasticity of tightness with respect to labor productivity as calculated using Shimer (2005)'s summary statistics is three times greater than that found by Elsby and Michaels (2008). That explains our data translation.

1.3 Model

To obtain analytical results and to gain some intuitions, we first consider the case of deterministic aggregate productivity and then later the dynamic stochastic case. We apply Delacroix (2006)'s formulation, which is somewhat different from Ebell and Haefke (2009), and allows us to develop a simpler model representation and save calculation steps without causing any changes to the model's outcome.

1.3.1 Basic environment

In the economy there are two markets: goods and labor. The former is characterized by a monopolistic competition according to Dixit-Stiglitz and the latter by a standard matching model (e.g. Pissarides (2000)). Monopolistic firms enter an industry by paying an entry cost and once this has taken place, they take households' demand for goods as given and choose the number of vacancies needed to maximize the discounted value of future profits. Households sell their units of labor supply to the labor market and buy goods from the goods market. A fraction of workers are unemployed and searching for a job while the rest are employed and face a certain probability of losing their jobs. All agents in the economy are risk neutral and discount their future payoffs at the rate r.

1.3.2 The goods market

There are H households in the economy and each is indexed by the subscript h and has a Dixit-Stiglitz preference for g differentiated goods. The economy is composed of g sectors and each specializes in a typical good i. Let $C_{i,h}$ be the quantity of goods i consumed by household h not surpassing its real income I_h. Let p_i and P be the price of goods i and the price index for all goods respectively.

The household h's utility maximization problem can be described as follows

$$\max_{C_{i,h}} \left(\sum_{i=1}^{g} \alpha_i^{\frac{1}{\sigma}} C_{i,h}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}},$$

subject to the budget constraint

$$\sum_{i=1}^{g} \frac{p_i}{P} C_{i,h} = I_h.$$

In the utility function for household h, σ represents the elasticity of substitution across consumption goods and α_i the weight assigned to goods i. In the symmetric equilibrium all goods are identical and thus $\alpha_i = 1/g$. The aggregate demand for goods i is obtained by solving the aforesaid problem

$$Y_i^D = \frac{1}{g} \left(\frac{p_i}{P} \right)^{-\sigma} I, \tag{1.1}$$

where $I = \sum_{h=1}^{H} I_h$ is the aggregate real income, and the composite price index P is defined by $P = \left(\sum_{i=1}^{g} \frac{1}{g} p_i^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$.

Suppose that all firms in one sector play the Cournot game, i.e, a firm takes other firms' output in its sector as given. Let N_i be the number of firms competing in sector i. The demand function for a particular firm, indexed by j, in this sector is therefore

$$\frac{p_i}{P} = \left[g \frac{Y_{i,j} + (N_i - 1)\overline{Y}_{i,-j}}{I} \right]^{-\frac{1}{\sigma}}, \tag{1.2}$$

where $Y_{i,j}$ is the output of firm j and $\overline{Y}_{i,-j}$ the average output for all $N_i - 1$ other firms. In symmetric equilibrium, all firms are identical so that $Y_{i,j} = \overline{Y}_{i,-j}$ and the subscript j be dropped giving the elasticity of demand faced by a firm in sector i as

$$\epsilon_i = \sigma N_i. \tag{1.3}$$

The elasticity of demand is the product of the elasticity of substitution across goods and the number of competing firms. Increase either σ or N_i will lead to an increase in the monopoly power ϵ_i. The former characterizes the degree of competition among sectors while the latter the degree of competition within each sector. In the literature however σ is often treated as a preference parameter, and thus throughout this paper the possibility of it becoming a measure of competition would be ruled out, thus the degree of competition is determined by N_i. As the number of firms specializing in a good increases, then the greater number of households able to choose to buy this good from different firms.

1.3.3 The labor market

Matching frictions

First, it is assumed that due to specialized skills households can only work in one sector. Frictions in the labor market however do not allow instantaneous meetings between firms and workers so that firms have to use its resources to find workers in the labor market. There are numerous sources of friction, as for example Pissarides (2000) tells us lack of coordination, asymmetric information, and heterogeneity of vacancies and workers, and all these factors can make matching costly. If a sector comprises a number of unemployed workers u_i and a number of vacancy positions v_i, then the number of hirings, denote by m, is a combination of these two variables. The matching technology is defined by a Cobb-Douglas function, as is the production function, which combines labor and capital input to produce output

$$m(u_i, v_i) = \mu u_i^{\eta} v_i^{1-\eta},$$

where μ measures the matching efficiency and η the unemployment elasticity with respect to match. The matching function is a reduced form representation of the frictions. Notice that m is (i) increasing and strictly concave in each separate argument, and (ii) constant returns to scale (CRS) in both arguments. As such, there are likely more matches when more workers and firms are searching, yet when holding an input constant, matching results in diminishing marginal returns. Let define labor market tightness as the ratio of vacancies to unemployment, $\theta_i = v_i/u_i$. It is convenient to define θ_i, as will be seen in the equilibrium, all model variables will depend only on it. Given the Cobb-Douglas form of the matching function, workers find new jobs at rate $f(\theta_i) = \frac{m(u_i,v_i)}{u} = \mu\theta_i^{1-\eta}$ while a vacancy is filled at rate $q(\theta_i) = \frac{m(u_i,v_i)}{v_i} = \mu\theta_i^{-\eta}$. When labor market tightness increases - either vacancy increases or unemployment decreases - it is easier for workers to find jobs but more difficult for firms to find workers.

A match between firm and worker can be broken either due to an unproductive match pair or a "death shock", which induces a firm to exit the industry sector. This model only considers the exogenous separation case. If for one period of time the firm's survival probability is δ_e, and the probability of a unproductive match pair is δ_s, then the average separation rate is $\delta = \delta_e + (1-\delta_e)\delta_s$. Let L_i be the current employment level in sector i, then L_i accumulates according to the following equation

$$L_i' = q(\theta_i)v_i + (1-\delta_s)L_i, \tag{1.4}$$

where the "prime" superscript indicates the next period. Eq. (1.4) states that next-period employment level is the sum of two flows: those who have just been hired and those who stay in the previous employment pool, except that one part of them moves out of that pool.

Steady-state value functions

Since the worker's optimization problem is found only in the goods market (the demand function for goods (1.1)), defining her value function is straightforward. The firm's optimization problem is however a bit more complicated as it will be based on the employment dynamic (1.4), and thus the problem will be written in dynamic form before being simplifying into a steady-state form. Let U and W be the values of being unemployed and employed respectively. In flow terms, they satisfy the following equations

$$\begin{aligned} rU &= b + f(\theta_i)[W - U], && (1.5) \\ rW &= w_i + \delta[U - W]. && (1.6) \end{aligned}$$

Eq. (1.5) states that a unemployed worker receives a flow income b which is common across sectors. At the rate $f(\theta_i)$, she meets an employment opportunity and, if taken, realizes a capital gain $W - U$. Likewise in Eq. (1.6), an employed worker in her sector is paid a wage w_i, and might lose the job at an exogenous probability δ associated with a utility loss $U - W$.

The value function for a firm is not habitually applied since as opposed to the MP model this model allows for multiple workers in each firm. Suppose for instance that a firm has already paid the entry costs for business entry. After this procedure, the firm must decide to post a certain number of vacancy positions v_i at the real unit cost κ in order to attract new workers for the next period. If any of these positions is filled then production starts with the technology given by

$$Y_i = y \cdot L_i, \tag{1.7}$$

where y represents labor productivity. Without changing the model implications, capital is excluded from the firm production function. Including capital can obviously help the model to gain more amplification because capital accumulation would expand output which in turn require the firm to hire more labor.

Let $V(L_i)$ be the firm's value function which depends on the current level of employment as this latter is a state variable. We follow Ebell and Haefke (2009) and Delacroix (2006) to assume that wage should be a function of L_i, given that its determination is based on the marginal surplus of each worker, the so-called intra-firm bargaining (IFB hereafter). IFB was first introduced by Stole and Zwiebel (1996) and further developed in a matching model context by Cahuc and Wasmer (2001) or Cahuc et al. (2000) to reflect the overhiring incentive in large firms, whereby they hire more labor to weaken the bargaining position of existing workers and therefore their salaries. In other words, by adjusting the size, firms can manipulate wages so as to vary the marginal revenue in case of imperfect competition or the marginal product in case of decreasing return. Therefore, each worker's pay is reduced, resulting in firms having an incentive to overhire. The IFB thus helps Ebell and Haefke (2009) in identifying significant decreases in real wage when competition increases and Delacroix (2006) in finding overhiring incentive in non-unionized sectors as compared to unionized sectors.

Given the IFB assumption, the firm's optimization can be written as follows:

$$V(L_i) = \max_{v_i, L_i'} \frac{1}{1+r} \left\{ \frac{p_i}{P} Y_i - w(L_i) L_i - \kappa v_i + (1-\delta_e) V(L_i') \right\}, \tag{1.8}$$

subject to

$$\begin{aligned} &\text{the demand function (1.2),} \\ &\text{the employment dynamic (1.4),} \\ &\text{the production function (1.7).} \end{aligned}$$

The first-order condition with respect to vacancy is

$$\frac{\kappa}{q(\theta_i)} = (1-\delta_e)\frac{\partial V(L_i')}{\partial L_i'}, \tag{1.9}$$

which means that the total cost of posting a vacant position equals the expected value of filling it.[2] Eq. 1.9 is the so-called job creation condition. Appendix A.1 shows that the steady-state version of job creation condition is equivalent to the following typical monopolistic price

$$\frac{p_i}{P} = \frac{\sigma N_i}{\sigma N_i - 1}\frac{1}{y}\left[\frac{r+\delta}{1-\delta_e}\frac{\kappa}{q(\theta_i)} + \frac{\partial[w(L_i)L_i]}{\partial L_i}\right]. \tag{1.10}$$

Eq. (1.10) provides a well known proposition: monopolistic firms charge a price that is higher than their marginal cost by an amount equal to the markups. Here the marginal cost comprises two parts: the vacancy costs and the marginal costs of hiring additional workers. The term $\frac{\sigma N_i}{\sigma N_i - 1}$ reflects the markup overs the total marginal cost. As will be shown in the equilibrium section, in the context of solving the unemployment volatility puzzle, Eq. (1.10) represents the key equation.

Wage bargaining

When a firm and a worker sit down to bargain over a wage paid, both parties make alternative offers until the agreement is concluded. The Nash product, which is based on the principle of sharing the total match surplus, is the solution to this type of negotiation game. With β being equal to the worker's bargaining power, wage is the outcome of the following optimization problem

$$\max_{w(L_i)} [W-U]^{\beta}\left[\partial V(L_i)/\partial L_i\right]^{1-\beta},$$

[2] Given $q(\theta_i)$ is the Poisson arrival rate of a new match for a firm, $1/q(\theta_i)$ is thus the average duration of a vacant position.

The first component in the maximization problem stands for the worker's surplus while the second the firm's marginal surplus of an additional worker. The usual F.O.C. delivers a standard differential equation for real wage as given by

$$w(L_i) = \beta \left[p_i y \frac{\sigma N_i}{\sigma N_i - 1} - \frac{\partial w(L_i)}{\partial L_i} L_i \right] + (1-\beta) r U_i. \tag{1.11}$$

which is quite intuitive. Real wage is the weighted average of the marginal benefit of adding a worker and her outside option. Going one step further, Appendix A.2 gives an explicit solution for real wage, as a function of labor market tightness

$$w(L_i) = b + \frac{\beta[(r + \delta + f(\theta_i)]}{(1-\beta)(1-\delta_e)} \frac{\kappa}{q(\theta_i)}. \tag{1.12}$$

Beveridge curve

Traditionally, the Beveridge curve describes the link between unemployment level and vacancy level in the steady state. If the flow out of unemployment $f(\theta_i)$ remains constant for a sufficiently long period and given the constant separation rate for all sectors then the sectorial unemployment rate converges to the steady-state rate

$$u_i = \frac{\delta}{\delta + f(\theta_i)}. \tag{1.13}$$

This is called the Beveridge curve in the $v - u$ space. Through normalizing the economy's total labor force to 1, for each sector the labor force becomes $1/g$ for reasons of symmetry. The sectorial employment level is thus the product of firm-level employment and the number of firms competing in the sector

$$N_i L_i = \frac{1}{g} \frac{f(\theta_i)}{\delta + f(\theta_i)}. \tag{1.14}$$

Eq. (1.14) is another presentation of the traditional Beveridge curve.

1.3.4 Equilibrium

The model is now ready to be closed. Let define a short-run general equilibrium and a long-run general equilibrium separately. The former is characterized by taking the degree of competition as given while the later by endogenizing the number of competing firms.

Short-run general equilibrium

Definition 1 *A short-run general equilibrium (SRGE) consists of a set of three endogenous variables $\{\theta_i, w(L_i), p_i/P\}$, for a given number of firms specializing in one good N_i, that satisfy the following system of equations:*

1. *the monopolistic price (1.10),*
2. *the wage equation (1.12),*
3. *the aggregate resource constraint*

$$I = \sum_{i=1}^{g} N_i \frac{p_i}{P} Y_i. \tag{1.15}$$

For reasons of symmetry, i.e., all goods are identical, the relative price is equal to unity so that $I = gN_iY_i$ and the aggregate demand function (1.1) is equal to the aggregate income and to the aggregate production. Expanding the SRGE system of equations makes it possible to obtain one equation, linking labor productivity y to labor market tightness θ_i

$$y = \frac{\sigma N_i - \beta}{\sigma N_i - 1} \left[b + \frac{r + \delta + \beta f(\theta_i)}{(1-\beta)(1-\delta_e)} \frac{\kappa}{q(\theta_i)} \right]. \tag{1.16}$$

Eq. (1.16) is a modified version of the *job creation* equation because it was directly derived from the firm's optimization problem. The existence and the uniqueness

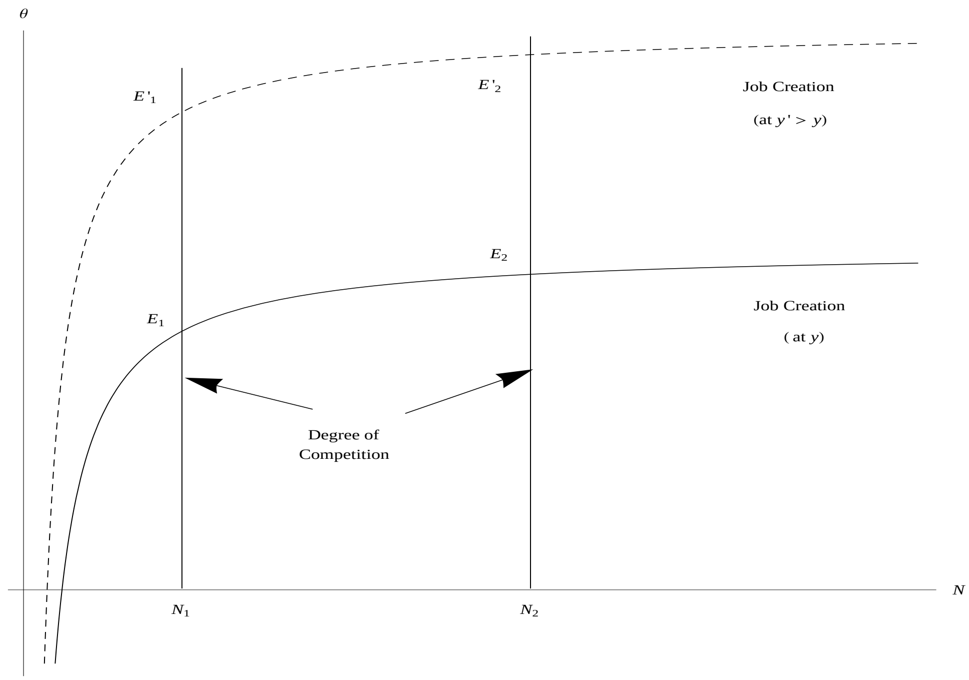

Figure 1.1 Short-run equilibrium and the effect of a positive aggregate shock

of the short-run general equilibrium (SRGE) are ensured under the condition that $y > \frac{\sigma N_i - \beta}{\sigma N_i - 1} b$ which means output per worker is higher than the non-market value corrected for the markups. This is so because the right hand side of (1.16) is strictly increasing in θ_i while its left hand side is a constant. The inequality is a necessarily condition to ensure that the constant line and the curve (the increasing function of θ_i) meet.

The SRGE is presented in Figure 1.1 where market tightness θ is a strictly increasing function of N. It is obvious from Eq. (1.16) that an increase in the degree of competition will further amplify the cyclical variation in θ.

Consider now the cyclical behavior of the labor market tightness θ_i following a positive productivity shock. The economy is initially at the equilibrium point E_1. If the labor productivity increases from y to a higher level y' then the equilibrium moves from E_1 to E_1' followed by an increase in the labor market tightness. If the degree of competition however increases from N_1 to N_2 for a particular reason such as high industry profits, then the equilibrium will move toward point E_2', leading further increase in θ_i. The intuition behind this is that in the short run, an increase in labor productivity increase output demand. Then, given that the price of goods and the markups remain unchanged, firms must hire more workers to meet the increased demand for goods. Overtime, higher industry profits attract more firms to enter the business and thus increase the degree of competition, leaving a smaller markups and alternatively, a further increase in job creation.

Long-run general equilibrium

The long-run general equilibrium (LRGE) is defined such that it allows N_i to be endogenized. In the short run, monopolistic competitors may either earn positive profits and attract new entrants, or operate at a loss, resulting in an industry shakeout. More particularly, the number of firms entering into business will have to respect the *free entry* condition, i.e., entry is allowed once the expected industry profits are driven to zero. The cut-off point, i.e., the maximum number of firms allowed to enter, is determined by equalizing the expected net present value of average profits from engaging in business and the costs of establishing a standard firm. In doing so, firms must take into account the exogenous probability of exiting from their sector δ_e. As such, the free entry condition is defined as

$$c_i = \sum_{t=1}^{\infty} \left(\frac{1 - \delta_e}{1 + r} \right)^t \pi_i,$$

where c_i is the entry costs which is taken as fixed costs because data may provide this kind of information. The term $\pi_i = \frac{p_i}{P} Y_i - w_i L_i - \kappa v_i$ is thus the current profit. After some algebra, the free entry condition is given by

$$c_i g N_i = \frac{1+r}{r+\delta_e} \frac{f(\theta_i)}{\delta + f(\theta_i)} \left[y - w(L_i) - \frac{\kappa \delta_s}{q(\theta_i)} \right], \tag{1.17}$$

Eq. (1.17) along with Eq. (1.10) determine the endogenous degree of competition and characterize the long-run equilibrium defined below:

Definition 2 *A long-run general equilibrium (LRGE) consists of a set of four endogenous variables* $\{\theta_i, w_i, p_i/P, N_i\}$ *that satisfy the following system of equations:*

1. *the monopolistic price (1.10),*
2. *the wage equation (1.12),*
3. *the aggregate resource constraint (1.15),*
4. *the free entry condition (1.17).*

Similar to SRGE case, one would need a condition to ensure the the existence and the uniqueness of the LRGE, which is $y > b$. Given w_i in (1.12), the long-run equilibrium system can be reduced to two equations with two unknowns (θ_i, N_i). The first equation is the job creation (1.16) which gives a positive relation between θ_i and N_i. The second equation is the free entry condition (1.17) which clearly shows a negative relation between θ_i and N_i. The condition for the two curves cut at a point is obtained by taking the limit of both curves when $N_i \to \infty$ and imposing the limit of the first equation higher than the second's one.

Consider the long-run equilibrium system in the $\theta_i - N_i$ space shown in Figure 1.2. A positive aggregate shock will increase the labor market tightness θ_i more in the long run than in the short run. This is because when N increases, the creation

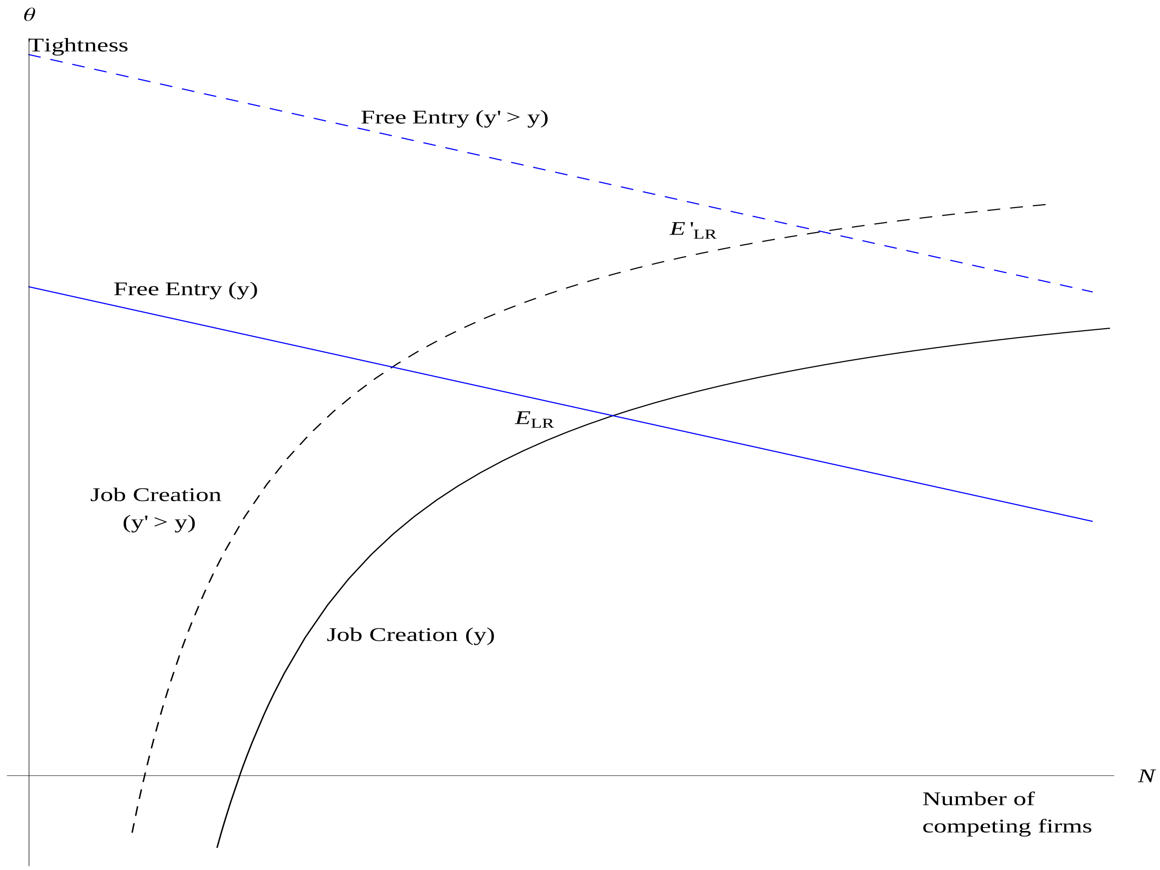

Figure 1.2 Long-run equilibrium and the effect of a positive aggregate shock

job curves diverge so that the variation in θ_i in the long run is higher than in the short run.

1.3.5 Dynamic version

To rewrite the model in a dynamic version and in continuous time, we follow the method used by Shimer (2005a). Suppose now that y is subject to aggregate shocks arriving at a Poisson probability λ which then change y to a new level y'. This new productivity is drawn from a first-order Markov process in continuous time. Let $E_y X_{y'}$ be the expected value of an arbitrary variable X, following the next aggregate shock, and conditional on the current state y. For simplification, the superscript will be omitted.

Now, given the state of the economy as it changes into a new one with probability λ, all value functions should be subject to this feature. The goods market however is unaffected by the latter because households' decision is a one-period optimization problem. The value functions for two types of workers are now changed to

$$\begin{aligned} rU_y &= b + f(\theta_y)[W_y - U_y] + \lambda[E_y U_{y'} - U_y], \\ rW_y &= w_y(L) + \delta[U_y - W_y] + \lambda[E_y W_{y'} - W_y]. \end{aligned}$$

For a firm, its value function satisfies

$$V_y(L) = \max_{v,L'} \frac{1}{1+r} \left\{ \frac{p_y}{P} Y_y - w_y(L)L - \kappa v + (1-\delta_e)[\lambda E_y V_{y'}(L') + (1-\lambda)V_y(L')] \right\},$$

subject to (1.2), (1.4) and (1.7). Denoted by $S_y = \frac{\partial V_y(L)}{\partial L} + W_y - U_y$ be the total surplus of a worker-firm match pair, Appendix A.3 shows that it must satisfy

$$rS_y = \frac{\sigma N_y - 1}{\sigma N_y} y \frac{p_y}{P} - b - \beta f(\theta_y) S_y - \delta S_y + \lambda [E_y S_{y'} - S_y]. \tag{1.18}$$

Therefore, the steady-state first-order condition with respect to vacancy is now given by

$$\frac{\kappa}{(1-\delta_e)(1-\beta)} = \lambda E_y q(\theta_{y'}) S_{y'} + (1-\lambda) q(\theta_y) S_y. \tag{1.19}$$

Rearranging (1.18) to yield

$$y = \frac{\sigma N_y - \beta}{\sigma N_y - 1} \left[b + (r + \delta + \beta f(\theta_y) + \lambda) S_y - \lambda E_y S_{y'} \right], \tag{1.20}$$

which is somewhat similar to the job creation equation (1.16), yet it now includes a new term resulted from the aggregate shocks. With a y vector and given N

is defined by the free entry condition (1.17), the system of equations (1.19) and (1.20) can be solved recursively to obtain a θ vector and a S vector. The dynamic version then appears to be new to the original paper by Ebell and Haefke (2009).

1.4 Numerical analysis

In this section, we first calibrate the model parameters in the static form and. In what follows, we simulate the model dynamic version and report the summary statistics as in Shimer (2005). We will only solve for the LRGE because the SRGE requires setting a fixed number of competing firms. The LRGE in particular is a more interesting case due to the endogenous degree of competition involved and when used to study business cycle facts, the mechanism results in more amplification.

1.4.1 Calibration strategy

The model's parameters are calibrated on a quarterly basis. For a summary of how they are computed, see Table 1.1. The deterministic aggregate productivity $y = 1$ is taken for normalization. The standard quarterly interest rate selected is $r = 0.012$, providing a consistent annual U.S. real interest rate of around 5%. The elasticity of substitution across goods $\sigma = 5$ is taken in the range estimated by a number of authors[3] The number of sectors $g = 13$ targets the estimates of markups in gross output that is about 1.15.

The most critical parameter is unemployment income b. As Hagedorn and Manovskii (2008) show labor market volatility depends mostly on this parameter yet the value they chose, $b = 0.95$, is spectacularly implausible. Various values of

[3] Christiano et al. (2001) and Rotemberg and Woodford (1995).

Table 1.1 Quarterly parameters

Parameter	Meaning	Source/Target
$r = 0.012$	interest rate	data
$\sigma = 5$	elasticity of substitution	Chistiano et al. (2001)
$g = 13$	number of sectors	markups
$\rho = 0.07$	entry costs	Djankov et al. (2002)
$\mu = 2.1$	matching scale	job finding prob.
$\eta = 0.5$	m elasticity w.r.t. u	Petrongolo & Pissarides (2001)
$\beta = 0.022$	workers' bargaining power	wage share
$b = 0.6$	unemployment income	OECD Unemployment Benefit & ...database
$\delta = 0.11$	separation rate	employment duration
$\delta_e = 0.03$	firm's survival prob.	median job tenure
$\kappa = 3.88$	vacancy cost	mean tightness
$\frac{\sigma N-\beta}{\sigma N-1} = 1.15$	markups	Data
$\mu\theta^{1-\eta} = 1.78$	job finding prob.	Shimer (2005b)
$4/\delta = 2.24$ years	employment duration	Shimer (2005b)
$\frac{Log(60\%)}{4Log(1-\delta_e)} = 4.2$	median job tenure	Scarpetta et al. (2002)
$\theta = 0.72$	mean tightness	JOLTS data

b have been used as for example: Shimer (2005a) sets $b = 0.4$, Hall (2005) and Mortensen and Nagypal (2007) 0.73, Elsby and Michaels (2008) 0.622, and Silva and Toledo (2008) 0.677. In the present model, we choose $b = 0.6$ as in Delacroix (2006) who refers to the OECD Unemployment Benefit Entitlements and Replacement Rates database (1997) as a database to evaluate unemployment income. According to the latter, 30% of the average output is devoted to unemployment insurance replacement rate and home production also accounts for 30% of average output. Adding these two sources yields a unemployment income of 0.6 which falls below the average of the range used by the literature.

To calibrate the parameters in the matching function, we refer to the monthly unemployment-to-employment flow estimated by Shimer (2005b), 0.594, as the job finding rate $f(\theta) = \mu\theta^{1-\eta}$. The average quarterly unemployment-to-employment flow should be approximately equal to the probability times the length of time, which is $3 \times 0.594 = 1.78$. We take the elasticity of unemployment with respect to match estimated by Petrongolo and Pissarides (2001), $\eta = 0.5$, for the matching function. We follow Pissarides (2009) to pindown mean market tightness in 1960–2006, which was 0.72, obtained from Job Openings and Labor Turnover Survey (JOLTS) data since December 2000 and the Help-Wanted Index (HWI) adjusted to the JOLTS units of measurement before then. This implied the matching efficiency parameter $\mu = f(\theta)/\theta^{1-\eta} = 2.1$.

We choose the average quarterly separation rate $\delta = 0.11$ to target the US structural unemployment rate of 5.9%. According to the 1997 OECD report on Distribution of employment by employer tenure, the median job tenure is 4.2 years. In Scarpetta et al. (2002), estimation of firms survivor rates at different lifetimes, the survival probability of a 4.2-year firm is 60%. Given that, the probability for a firm to exit itself each quarter is $\delta_e = 1 - 0.6^{1/(4\times 4.2)} = 0.03$. Thus, the probability of a unproductive match pair is $\delta_s = (\delta - \delta_e)/(1 - \delta_e) = 0.082$.

We follow the study done by Djankov et al. (2002) to take a fraction ρ of the annual per capita GDP devoting to entry costs. On a quarterly basis, the fraction should approximately be $\rho = 7\%$. This entry costs including start-up and administration costs appear to be realistically low since entry requires sunk investments. For this reason, we also include in the entry costs an amount equal to the initial hiring costs or the total costs of finding just L employees needed to start the production process. Since all the population is available to work, the per capita GDP is then equal to the aggregate output divided by the labor force, $y(1 - u)$. Hence

$$c_i = \rho y(1 - u) + \kappa u \overline{\theta}, \tag{1.21}$$

where $\overline{\theta}$ is the mean tightness.

The literature on matching models often imposes $\beta = \eta$ to satisfy the Hosios' efficient condition (Hosios (1990)). In this model, $\beta = 0.022$ is chosen to target the wage share (2/3) observed in the aggregate data level. Notice that within the current debate, a fairly low value of β may not be very convincing, but it is quite consistent with the range [0.01;0.08] estimated by Blanchfower et al. (1996) and Hildreth and Oswald (1997). Other study also finds low β as for example Delacroix (2006) who finds $\beta = 0.045$ to represent the 7% of the relative difference between union and non-union wages. The work by Hagedorn and Manovskii (2008) sets $\beta = 0.052$ in order to target the elasticity of real wage with respect to labor productivity of 0.5. Finally, in order to target the average tightness $\theta = 0.72$ we need to set $\kappa = 3.88$.

1.4.2 Simulation results

Consider the stochastic process of the aggregate shock described in Appendix A.4 which delivers the simulation results in the last row of Table 1.2. To see how well the model performs in terms of labor market volatility, we compare it to the data and the literature discussed in Section 1.2. We can also evaluate the model in some additional dimensions. For example, implications for the markup and firm entry could be compared to the business cycle literature. Shimer (2005)'s summary statistics of quarterly U.S. data and his simulation results of the MP model are reported in the first and the second row. It becomes clear that the standard model fails to obtain the labor market volatility seen in the data. In the third row of this table, we include the results of Hagedorn and Manovskii (2008) who simulate the standard model with high unemployment income (b=0.95) and this strategy explains all or even more volatility in the data since $\frac{Std.(\theta)}{Std.(y)} = \frac{0.292}{0.013} = 22.46 > 19.10 = \frac{0.382}{0.02}$ and the elasticity of tightness with respect to shock is, as Costain and Reiter (2007) pointed out, unrealistically high (21.72 vs. 7.56). Hagedorn and Manovskii (2008) use the standard smoothing parameter for quarterly data

Table 1.2 Volatility and cyclical behavior of labor market variables

	Std.(u)	Std.(v)	Std.(θ)	Std.(y)[a]	Elas.(θ/y)	Elas.(w/y)	Wage share	Entry rate	Elas. (markups/y)
Data	0.190	0.202	0.382	0.02	7.56	0.5–1[b]	0.67	0.62%[c]	[-0.16,-0.02][d]
Shimer	0.009	0.027	0.035	0.02	1.75	1	0.98		
HM	0.145	0.169	0.292	0.013	21.72	0.5	0.97		
Model	0.07	0.097	0.159	0.02	5.99	0.6	0.67	0.93%	-0.14

[a] Targeted.

[b] Pissarides (2009)

[c] Annual Survey of Manufacturers panel data from Campbell (1998), Table 1.

[d] Martins et al.(1996), Table 6.

(1600) which is much less smooth than the one used by Shimer (2005a) (10^5) so that why they obtain lower standard deviation but the relative standard deviation is unchanged. Note, however, that both Shimer and HM generated wage share is relatively very high as compared to the data. HM calibration targeted the cyclicality of real wage based on aggregate data level and Shimer generates a proportional wage elasticity while Pissarides (2009) inspects microdata level on wage and finds that wage is strongly procyclical. The latter argues that since wage derived from the Nash bargaining rule represents the negotiation between an individual and a firm so that it should reflect the individual or microdata level. Our parametrization yields a somewhat low elasticity of real wage due to the relatively low wage share. But only wage rigidity, as shown by Hagedorn and Manovskii (2008), is not enough to amplify volatility and it is the unemployment benefits the key parameter. In the fourth row, our simulation results indicate that monopolistic competition under plausible calibration can generate up to 50% of the the labor market volatility, which is a substantial improvement. For the entry rate measured as the net change en percentage of the number of entering firms, the eighth column of the table shows that our model generates a rate higher than the data level provided by Campbell (1998). This might be due to the fact that the data used to calculate the entry rate is the Annual Survey of Manufacturers where manufacture firm size is generally large and different across firms while in our model, all firms are identical. Yet another reason is that our low value of β allows firm to extract almost the match surplus which in turn implies higher entry rate in responding to aggregate shocks. The last column shows the countercyclical markups which are in the range estimated by Martins et al. (1996) who use U.S. panel firms data for different industries.

Table 1.3 shows the simulation results for the persistency of and the link between labor market variables as shown in Shimer (2005). In terms of quarterly autocorrelation and with the exception of unemployment and tightness, model vacancy does not fit the data well. The correlation between unemployment and vacancy - the Beveridge curve very close to the data (-0.871 vs. -0.894), yet the correlation between unemployment and and labor productivity is far from the data (-0.864 vs. -0.408). This result, although it remains unexplained, still represents a significant improvement for the model.

Sensitivity analysis

Our low value of worker bargaining power might be subject to criticism because the literature often imposes a value $\beta = \eta = 0.5$ to satisfy the efficient condition. To see how sensitive the model results respond to changes in this parameters while respecting the calibration strategy as in the baseline case for targeting the markups of 1.15 and the mean tightness of 0.72 so that the two parameters g and κ change accordingly: for β equal to $\{0.5, 0.3, 0.1\}$, the pair (g, κ) are set to

Table 1.3 Autocorrelation and correlation matrix

		u	v	θ	y
		Data: 1951I-2003IV			
Autocorrelation		0.936	0.940	0.941	0.878
Correlation matrix	u	1	-0.894	-0.971	-0.408
	v		1	0.975	0.364
	θ			1	0.396
	y				1
		Shimer			
Autocorrelation		0.939	0.835	0.878	0.878
Correlation matrix	u	1	-0.927	-0.958	-0.958
	v		1	0.996	0.995
	θ			1	0.999
	y				1
		Hagedorn and Manovskii			
Autocorrelation		0.830	0.575	0.751	0.765
Correlation matrix	u	1	-0.724	-0.916	-0.892
	v		1	0.940	0.904
	θ			1	0.967
	y				1
		Model			
Autocorrelation		0.918	0.733	0.849	0.877
Correlation matrix	u	1	-0.871	-0.954	-0.864
	v		1	0.977	0.872
	θ			1	0.893
	y				1

$\{(45, 0.32), (29, 0.69), (18, 1.92)\}$ respectively. Tables 1.4 and 1.5 report the volatility and cyclical behavior of labor market variables and the autocorrelation and correlation matrix respectively. Overall when β varies, the volatility of unemployment, vacancy and tightness do not vary much while the elasticity and the entry rate and the markups respond strongly to productivity shocks. The correlation matrix is much improved for the case $\beta = 0.5$ as compared to the data in Table 1.3, and neither Shimer (2005) nor Hagedorn and Manovskii (2008) could improve the correlation matrix results as labor market variables are strongly correlated with with y, 0.95 on average, while the correlation coefficients provided by the data are relatively small, 0.4.

Table 1.4 Volatility and cyclical behavior of labor market variables: sensitivity analysis

	Std.(u)	Std.(v)	Std.(θ)	Std.(y)[a]	Elas.(θ/y)	Elas.(w/y)	Wage share	Entry rate	Elas. (markups/y)
$\beta = 0.5$	0.049	0.072	0.115	0.02	3.52	1.01	0.85	0.16%	-0.024
$\beta = 0.3$	0.05	0.073	0.117	0.02	3.68	1.00	0.84	0.25%	-0.038
$\beta = 0.1$	0.057	0.081	0.131	0.02	4.38	0.93	0.77	0.51%	-0.077

[a]Targeted.

1.5 Conclusion

The unemployment volatility puzzle has attracted numerous works to develop an effective mechanism for the standard search and matching model in order to understand why key labor market variables such as unemployment and vacancy have responded widely to change in aggregate shocks. As argued by Shimer (2005a), the Nash bargaining solution used to determine wage is responsible for this. In the model, wage is negotiated according to the rule for surplus sharing, whereby an increase in labor productivity will increase wage by the same proportion. As such, firms' profits will remain unchanged over the business cycle, meaning they have little incentive to create jobs and thus the model exhibits a moderate level of labor market volatility. Although some modifications of the model, for example Hagedorn and Manovskii (2008), might bring the model' prediction close

Table 1.5 Autocorrelation and correlation matrix: sensitivity analysis

		u	v	θ	y
			$\beta = 0.5$		
Autocorrelation		0.878	0.619	0.771	0.877
	u	1	-0.823	-0.932	-0.571
Correlation matrix	v		1	0.972	0.577
	θ			1	0.589
	y				1
			$\beta = 0.3$		
Autocorrelation		0.884	0.637	0.783	0.877
	u	1	-0.831	-0.936	-0.621
Correlation matrix	v		1	0.973	0.628
	θ			1	0.641
	y				1
			$\beta = 0.1$		
Autocorrelation		0.901	0.687	0.817	0.878
	u	1	-0.855	-0.946	-0.747
Correlation matrix	v		1	0.975	0.755
	θ			1	0.771
	y				1

to the data, the parameterization used has been subject to a great deal of criticism. This motivated this research to develop a simple matching model with monopolistic competition.

Our approach is relatively different to the literature, that of monopolistic competition among active firms which can enhance significant labor market volatility under plausible parameters. The key element that helps us to get more volatility in labor market variables is procyclical entry of firms that produces countercyclical markups. The sensitivity analysis has shown that even with the standard parameterization, the model provides a substantial improvement in the labor market volatility as compared to the standard search and matching model. The only problem that we are concerned is the low calibrated value of workers' bargaining power $\beta = 0.022$ in the baseline case, yet literature on matching models has never paid any attention to the wage share in the data which relatively lower than the one generated by the literature. A low wage share also produces weak procyclicality of real wage as shown by our simulation results. The value of β (0.5) often used by the literature might however lead readers to ask the following question: "Do workers really have the same power of negotiation as employers?". "Yes" may be a convincing answer if these workers are highly skilled workers (e.g. university professors, doctors, CEOs, etc) but if most of them are not then putting them in the same position as employers is quite "uncomfortable". Unemployment should be the key factor in determining workers' bargaining power, though it was not explicitly modeled. The majority of the labor force has experienced that the cost of being unemployed was both economically and psychologically large, it's therefore reasonable to argue that workers' bargaining should be low.

CHAPTER II

THE EFFECTS OF THE HUKOU SYSTEM OF HOUSEHOLD REGISTRATION ON LABOR MARKET IN CHINA

We study the effects of the Chinese Hukou system of household registration (the law that limits migration the rural to the urban areas and vice-versa) on labor market outcomes. We develop a search equilibrium model of migration in a worker heterogeneity context. We find that if the Hukou system of household registration is relaxed by either decreasing the law enforcement or allowing more people to live in the city, urban unemployment rate would be reduced, and more particularly the social welfare would be increased.

Keywords: Hukou system, worker heterogeneity, developing countries

2.1 Introduction

In many countries, including the most developed, the existence of an informal (unregulated) sector has made it possible for many of the country's poor to survive. In developing countries, the informal sector represents a very important part of the economy, creating jobs not only for the poor and also those who have lost their jobs and receive no financial assistance from the government. According to statistics on developing countries provided by the International Labour Organization (ILO), the proportion of the labor force participating in the informal sector may vary from 30% to 70%. In China, the informal sector concept did not appear until the late 1980s and 1990s, following several attempts made by the Chinese government to reform the labor market.Prior to these periods, China had a centralized economy governed by the Communist Party and most urban workers were lifetime employed in the state- and collectively-owned enterprises (Knight and Yueh (2004)). The most relevant labor market reforms resulted from government efforts to reduce surplus labor in the state-owned enterprises (hereafter SOE) and the relaxation of the Hukou household registration system. According to Appleton et al. (2002), more than 25 million SOE workers were laid-off between 1996 and 1999. At this same time restrictions on rural-urban migration linked to the hukou system were relaxed, leading to the massive numbers of people migration from rural to urban areas. The result was in increase in urban unemployment thus placing more pressure on the government to resolve many employment issues. Solutions adopted and promoted included the creation of private enterprises and an increase in economic activities in the informal sector. Indeed, as they took on informal jobs, many workers were better off than before, especially in terms of income (ILO 2002 statistics). Recently, the OECD estimated China's unemployment and based on the 2000 population census found that those making up the informal sector were mainly i) rural migrant workers who because of the hukou registration system could not work in registered enterprises; and ii) laid-off workers from state enterprises who took informal employment on a temporary basis while remaining nominally attached to their previous work units in order to obtain welfare benefits and re-employment opportunities.

In this paper, we focus essentially on the effects of the Hukou system of household registration. The Hukou law restricts labor mobility between countryside and city, and between city and city. In fact, a person holding rural Hukou status cannot work in the urban areas and vice-versa. If a rural Hukou holder moves to the city or a urban Hukou holder moves to the countryside, both are considered as illegal migrants. As the Hukou system has been proved to be responsible in rising social inequality and discriminating against migrant workers, many prominent scholars have recommended the Chinese government to put the rule out of effect. Regarding whether or not the system should be abolished still remains a greatest challenge faced by the Chinese government, although many reforms have been made since 1980s and 1990s.

There are few studies applying the standard search and matching model to developing countries context so we develop this model in a worker heterogeneity environment and quantify the effects of relaxing the Hukou system on the labor market outcomes. We find that if the Hukou system of household registration is relaxed by either decreasing the law enforcement or allowing more people to live in the city, urban unemployment rate would be reduced. Moreover, the social welfare defined by the sum of the utilities of the employed and the unemployed, the production of the firms net of search costs would increase. In the first case, i.e, keeping the number of Hukou status unchanged while lightening up the detection of the illegal workers in the urban sector, that would help the urban sector become more attractive to rural residents, so firms hiring both illegal and legal Hukou status would benefit more from illegal worker since the rent firms extract from illegal workers is higher than that from legal workers and this in turn would induce firms to create more vacant positions. In the face of quick economic and social change in China, it is likely that the Hukou system will not be maintained in the future and there is a greater likelihood that workers prefer to work in the urban sector where more job opportunities with higher income, as compared to the rural sector.

The model presented in this paper is built in the sprit of the Laing et al. (2005) model (hereafter LPW model). The LPW is an extension of the classical Harris-Todaro rural-urban migration model (Torado (1969) and Torado and Harris (1970)) to allow for job search in the urban areas. The classical Harris-Todaro model is a behavioral model of migration whereby rural workers decide to migrate to the urban areas based not only on wage differentials but also on the probability of finding a job at the prevailing wage, i.e., migration decision is based on expected-income differentials, adjusting for migration costs. It turns out that in this kind of model there is a scenario in which all rural workers will migrate to the urban areas whenever the net benefits from migration exceed the migration costs. In the LPW model, the view of migration is different from the classical models as it assumes that there should be no migration in equilibrium. In other words, not all rural workers will migrate to the urban areas, even though expected-income differences between two regions are present. Moreover, labor turnover becomes an additional source that contributes to deter migration in China, especially migrant workers often face higher risk of no-employment due to the presence of Hukou law. This reduces the fraction of illegal migrants and therefore urban unemployment rate.

Worker heterogeneity in our model can be thought of as not all workers would like to live in the countryside and not all workers would be qualified for urban sector jobs. In other words, the least productive workers do not find profitable to move to the cities and stay in rural areas. Another feature that distinguishes our model from the LPW model is the way the law affects workers. In the LPW model, the law directly affects the supply side directly via the migration channel. In our context, the law affects not only the supply side but also the demand side because of variation in the firm's match surplus when it hires an illegal migrant.

The approach to worker heterogeneity in our model is adapted from the work done by Albrecht et al. (2009). These authors introduce worker heterogeneity to analyze the effects of severance payments and payroll taxes on informal and formal sector outputs, on the division of workforce into unemployment, informal employment and formal employment, and on wages in four large Latin American economies: Argentina, Brazil, Colombia and Mexico. It is an extension of the standard Mortensen and Pissarides (1994) model for an economy consisting of substantial activity in the informal sector. According to them, high productivity workers transfer to formal sector jobs while those in the lower one can only work in the informal sector, with some in between working in both sectors. The ANV model differs from the approach used in this paper in several dimensions. First, the agriculture constitutes an additional sector in the country's economy. Second, there are no idiosyncratic shocks. Third, as in the LPW model, illegal workers in the urban sector suffer from faster break-down rates resulting from the law. Finally, it has been claimed that employment protection legislation in developing countries is very weak. This is true in China in particular. Most employed workers do not pay income taxes, such that in this model severance payments and payroll taxes are precluded elements.

Apart from the papers by Laing et al. (2005) and Albrecht et al. (2009), relatively few studies apply the search equilibrium model within the developing country context. As a means of explaining the existence of a sizeable informal sector in developing countries, Satchi and Temple (2006) develop a general equilibrium model focusing on the importance of matching friction in explaining the existence of a sizeable informal sector in developing countries. As such they investigate how labor market institutions affect aggregate productivity and sectoral structures. Their model allows rural workers to seek higher pay jobs in the formal sector although they undergo search costs, and before beginning this process they have to enter the informal sector, meaning they incur migration costs. Zenou (2008) applies a method somewhat similar to that of Satchi and Temple (2006), but he focuses on the negative effects that unemployment benefits financed by taxes on firms' profits have on formal job creation and the size of the informal sector, and on the ambiguous effects on wages. Bosch and Esteban-Pretel (2009) put the unemployment volatility puzzle - the standard search and matching model's failure to generate a significant magnitude of unemployment fluctuations over the business cycle - into the context of an economy having adequate activity in the informal sector, such as in Brazil.

The fact that illegal workers in our model suffer from higher probability of loosing job is also closely related to the study done by Boeri and Garibaldi (2005). Their model comprises two sectors, shadow and legal, where those in the shadow sector are allowed to post vacant positions. The difference between the two sectors is that employed workers in the legal sector pay taxes and unemployed workers receive compensation, while in the shadow sector no transfers take place, but employed workers face law-enforcement monitoring. These authors show that there is a cut-off skill level that sorts workers into each sector, with the more productive workers relocating into the legal sector. Our model differs from theirs in that it allows the existence of a rural sector and analyses the direct effect of law-enforcement monitoring on the rural-urban migration flow.

The approach we use to model the rural sector is similar to the work done by Gutierrz et al. (2009). To accommodate the existence of the agriculture sector they extend the ANV model and study the economic consequences of financial crises on Nicaragua's labor market. They find that economic shocks have only modest effects on employment but significant effects on worker relocation across sectors. The model present in this paper is different in the sense that we focus on the presence of the Hukou law.

In the remainder of this paper, Section 2.2 provides a brief overview of the Hukou system and a recent debate on the economic effects of implementing the related law. In Section 2.3 a theoretical model is developed while Section 2.4 provides the numerical analysis undertaken to quantify the impact from labor market policy. Finally, Section 2.5 concludes.

2.2 The Hukou system and its economic literature

This section provides a brief overview and a recent debate on the economic effects of implementing the law. For a detailed history and the evolution of the Hukou system, see Liu (2005), Zhao (2003) or Afridi et al. (2009).

Right after the Chinese Communist Party took power of the country in 1949, rural migrants flooded into the major cities to look for better job opportunities, causing numerous social problems. In response to this the Chinese government introduced the Hukou system two years later, but only in urban areas. The officially stated purpose was to maintain social peace and order, safeguard the people's security, and protect their freedom of residence and movement. Under this system, only urban Hukou holders could access to social programs such as housing, social insurance, health care, etc., and as a result, the flood of rural migrants continued to expand, forcing the government to circulate a directive in 1955 and extend this law into rural areas. This directive was intended to prevent unplanned migration between rural and urban areas and between cities, and became received official sanction for any change of residence. At the time, almost all urban jobs were allocated and controlled by the SOEs and through a supervisory office (the State Labor Bureau), authorized to assign employment to urban residents only. Rural or urban Hukou holders were considered illegal migrants if they worked in a city in which they were not permanent residents.

Until 1998, children could not get into urban schools if their mothers held rural Hukou status, while rural residents could obtain urban Hukou status through two main channels: formal and informal (Xing (2009)). Those obtaining urban Hukou through formal channels consisted of workers being hired by the SOEs), joining the army, obtaining university degrees or performing in national sport teams. Informal channel included those whose lands had been occupied by urban construction projects and were buying houses in the urban areas.

The Hukou system thus created a huge surplus of rural workers that could not be absorbed in the rural areas. Thus in 1983 the state allowed rural households to take up jobs in market towns, without changing their residence. In 1984, peasants were officially permitted to work or do business in cities and as such local governments were authorized to issue a temporary residential permit to those finding legitimate jobs in the city, and a blue-stamp Hukou (blue card) to investors, property buyers and professionals sponsored by major enterprises. Holders of blue cards enjoyed more government benefits than those holding temporary residential permits. The blue cards in fact functioned more like regular Hukou, and within 2 to 5 years there was a good chance of obtaining regular urban Hukou cards. As of 1990, rural residents could obtain urban Hukou status by paying a one-time entry fee varying from a few thousand yuan in small cities and towns to 50,000 yuan in major cities. Today, local governments still require some business firms to hire only local residents but the level of enforcement has diminished somewhat.

Studies on the economic and social impacts of Hukou system are numerous. This is especially true among certain empirical works, most of which quantify the law's effects on the welfare of rural migrants and on wage inequality across rural and urban areas and within these regions. Using the 1997 Beijng Migrant Census, Guo and Iredale (2004) show that a university degree and a non-agricultural registration status could both lead to increased access to employment in the formal sector and that qualified migrants were able to penetrate the formal job market, even though most migrants are still restricted to low level jobs in the informal sector. Liu (2005) uses a household data survey from the 1995 Chinese Household Income Project to examine the impacts on social and economic of urban residents. He found for example that people who obtained urban Hukou later in their lives tended to benefit less from social protection such as government heath care benefits, pension and subsidies, had lower education levels and remained unemployed for longer periods of time. Afridi et al. (2009) conducted themselves an experimental study in which they investigated the impact of migrant status on individuals' responses to economic incentives. They found that making individuals' Hukou status salient and public would decrease the performance levels of rural migrant children assigned certain tasks by 12%, resulting in lower income rankings for rural migrants and placing them at the lower end of income distributions. A recent study by Huang (2010) has shed new light on the causes of decreased consumption rates during the period 1993-2007 while household average saving rates among Chinese consumers had not increased. This was explained by the lack of social benefits applied to rural migrant workers, who, compared with their urban Hukou counterparts, had stronger precautionary saving motivation. More particularly, children's education levels were found to be the most significant factors in their precautionary saving motivation. Rural migrants whose children and family live in a city are not able to send their children to local school systems but they can send them to private schools run by entrepreneurs, even though they are usually very expensive.

At the theoretical level little has been done to explore the Hukou system's effects on China's labor market. Apart from the work by Laing et al. (2005), another approach was proposed by Whalley and Zhang (2007). In this model they simulated a general equilibrium model incorporating specific factor inputs and downward sloping marginal labor products, and confirmed that the Hukou system was responsible for general increases in wage inequality in China. The approach we have applied in this paper that differs from that found in the theoretical literature in that worker heterogeneity is a key factor when assigning workers to each sector.

2.3 Model

The structure of the model is essentially based on Laing et al. (2005) with the worker heterogeneity approach taken from Albrecht et al. (2009).

2.3.1 Basic environment

Consider a continuous time economy in which workers and firms are risk neutral and discount their future payoffs at the rate r. The economy is divided into two regions, the rural sector and the urban sector. Normalizing the total labor force to one, if N is assumed to be the mass of residents who are legally obliged to live in the rural sector then the mass of workers permitted to move to the city is thus $1 - N$. One way for the Chinese government to reform the Hukou system in favor of rural Hukou holders is to allow more workers to live in the city, i.e., that is to decrease N. The rural labor market is perfectly competitive where there is no unemployment while the urban labor market is frictional where job search is costly for both firm and worker, and a worker meets a firm by a random matching process.

Workers are different in terms of their residency status: (i) urban Hukou holder denoted by the superscript C; and (ii) rural Hukou holder denoted by M. If a rural Hukou holder moves to the city or a urban Hukou holder moves to the countryside, both are considered as illegal migrants and thus two-way migration can take place. For each residency status C and M, there is a continuum type of workers with each type being denoted by y and drawn from its specific cumulative distribution function $G^C(y)$ and $G^M(y)$ respectively. These features make our model different from the LPW model. In particular, we assume that both $G^C(y)$ and $G^M(y)$ are the standard uniform distribution over $[0; 1]$.

Denoted the mass of rural worker, urban employed worker and urban unemployed worker by (N_a, E, U) respectively, we have:

$$N = N_a^C + E^M + U^M \text{and } 1 - N = N_a^M + E^C + U^C.$$

Migration is based on the expected value across regions. In steady-state equilibrium, there is no migration per se. Otherwise, a mass of workers would jump from one sector to another. As such, this paper is not a typical behavioral rural-urban migration model as the classical Harris-Torado model. It is not that agents are born in a location (rural or urban) and with a y and then decide to migrate or not; rather it is a model where a worker, born with a type y, chooses a sector to live in. That means, more highly skilled worker is more likely to be found in the urban areas, and a worker chooses to move to the countryside because living in the city would not necessarily be a better option.

When applying for a job, all agents must present their Hukou status. Illegal migrants in the urban area can search for job but if they successfully find one, they suffer faster job break-up rate due to the enforcement of the Hukou law. Therefore, decreasing the law enforcement is another way that helps rural Hukou holders establishing their life in the urban areas where job pay is generally higher than in the rural areas.

Beside the assumption of perfect competition in the rural labor market, we assume that every worker regardless of his productivity and residency status earns the same income. If the agriculture production function is $Y_a = A_a N_a^{\phi}$, where $N_a =$

$N_a^C + N_a^M$, $A_a > 1$ is the agriculture production technology parameter and $\phi < 1$ reflects decreasing marginal return of labor, then agriculture output per worker is therefore:

$$y_a = \frac{Y_a}{N_a} = A_a(N_a^C + N_a^M)^{\phi-1}. \tag{2.1}$$

This equation has an intuitive interpretation: given the fixed amount of land available for production, the greater number of rural residents, the lower income earned by each worker in the rural area.

In the urban area, there is an infinite number of firms that can hire both types of Hukou status. There is a mass of V vacant positions and each position costs c amounts of money. Also, firms can freely enter into the urban labor market and can exit it without cost. With the aggregate mass of unemployed workers in the economy is $U = U^C + U^M$, the number of hires is a function of both U and V and is denoted by $m(U, V)$. As a standard assumption, the matching function takes the Cobb-Douglas form:

$$m(U, V) = \mu U^\eta V^{1-\eta},$$

where μ measures the matching efficiency and η the unemployment elasticity with respect to match. Define $f(\theta)$ and $q(\theta)$ the rate at which a unemployed worker and a firm contact the other party where $\theta = V/U$ is called the labor market tightness. Since firms can contact both legal and illegal worker, given $q(\theta)$, the probability a firm meets an illegal worker is:

$$p = \frac{U^M}{U^C + U^M}.$$

Upon a successful match, firm pays an illegal worker a fixed wage, and a legal worker a Nash bargaining wage. The assumption of fixed wage received by illegal workers regardless of their productivity might not be realistic but there are some reasons to make it. For example, firms hiring illegal workers know that those workers don't have urban Hukou status so that firms want to extract more surplus from the match relationship and therefore pay fixed wage. Another possibility is that before relocating to the city, rural migrants might accept an expected fixed amount of income in the hope that later they can get the urban residency.

If we assume s is the probability legal workers lose their job then there is a higher probability $s + h$ that their illegal counterparts should lose their, due to the Hukou system. For reasons of simplicity, both s and h are exogenous, as the firm's job destruction behavior and the city's enforcement behavior are not explicitly modeled in this context.

2.3.2 Steady-state values

Since the rural labor market is perfectly competitive, the steady-state flow value of an individual rural worker is thus his income:

$$rA(y) = y_a,$$

where y_a is given by Eq. (2.1), reflecting the assumption that every worker in the rural area regardless of his productivity and Hukou status earns the same fixed income.

Let $J^i(y)$ be the value of a urban firm employing a type y worker and J_v be the value of a vacant position. Let $(W^i(y), S^i(y))$ be the values of a worker of type y who is employed and unemployed in the urban area respectively, where $i = C, M$.

For the category C, the flow value functions can be written as

$$\begin{aligned} rJ^C(y) &= A_1 y - w(y) + s[V - J^C(y)], \\ rW^C(y) &= w(y) + s[S^C(y) - W^C(y)], \\ rS^C(y) &= b + f(\theta)[W^C(y) - S^C(y)] \end{aligned}$$

Eq. (2.2) states that a urban firm hiring a urban Hukou holder of type y is given a flow output $A_1 y$ where A_1 is the technology parameter, and in the case of match dissolved at rate s, the firm incurs a capital loss of $J_v - J^C(y)$. An urban Hukou worker is paid a wage $w(y)$ depending on his type, and the match can be broken at rate s. A unemployed worker holding legal urban Hukou enjoys a non-market income b and finds job opportunity at rate $f(\theta)$ and if the opportunity is taken, he realizes a capital gain of $W^C(y) - S^C(y)$.

For the category M, the flow values are given by:

$$\begin{aligned} rJ^M(y) = &\quad A_1 y - y_0 + (s+h)[J_v - J^M(y)] && \text{if } A_1 y \geq y_0; \quad 0 \text{ otherwise}, \\ rW^M(y) = &\quad y_0 + (s+h)[S^M(y) - W^M(y)] && \text{if } A_1 y \geq y_0; \quad 0 \text{ otherwise}, \\ rS^M(y) = &\quad f(\theta)[W^M(y) - S^M(y)] && \text{if } A_1 y \geq y_0; \quad 0 \text{ otherwise}. \end{aligned}$$

which differ from those of category C in three points. First, an illegal migrant is paid a fixed income y_0 if he successfully finds an urban job, independent of his productivity. Firms hire illegal workers only if the match surplus is positive, $J^M(y) \geq 0$. Since the economy has an infinite number of firms and entry is costless, therefore the value of posting a vacancy is zero in steady-state equilibrium ($J_v = 0$). The condition needed to form a firm-illegal worker pair is thus $A_1 y \geq y_0$. Otherwise, it is not worth for a firm to hire illegal workers. Second, the probability a legal rural Hukou holder looses his job is higher than the legal city Hukou counterpart. Here the additional probability of match break-up h is captured by

Hukou law enforcement. Finally, there is no unemployment benefits distributed to illegal unemployed workers. In equilibrium, it is expected that these three flow values cannot be equal to zero.

A vacant firm's flow value does not depend on y since the firm does not know in advance what type of worker it will meet, hence

$$rJ_v = -c + q(\theta)E\mathtt{max}[pJ^M(y) + (1-p)J^C(y) - J_v, 0],$$

where p is the proportion of searching workers who are illegal urban Hukou. In this flow value, the expectation operator must be taken into consideration across the distribution type y among the unemployed as a firm may meet either a low productivity worker, and in this case it is not worth forming a match. In the equilibrium, free entry of firms drives J_v to zero.

2.3.3 Legal employed's wage determination

Given $J_v = 0$, a legal Hukou worker-firm pair in the urban sector generates a total matched surplus $W^C(y) - S^C(y) + J^C(y)$. Let β be the worker's bargaining power, then the wage a legal city Hukou employed worker earns, $w(y)$, becomes the solution to the following Nash sharing rule $\max_{w(y)} \left[W^C(y) - S^C(y)\right]^{\beta} J^C(y)^{1-\beta}$. Solving this optimization problem yields

$$w(y) = \beta A_1 y + (1-\beta)rS^C(y). \tag{2.2}$$

2.3.4 No-migration conditions

Notice that most migration models do not impose an equilibrium condition that requires no migration can take place as they are naturally behavioral models that focus on individuals' migration decision. An individual decides to migrate from one place to another if the net benefits from migration exceed the migration costs. It turns out that in this kind of model there is a scenario in which all rural residents will migrate to the urban areas whenever the net benefits from migration exceed the migration costs. In our model however, there is no migration in the steady-state equilibrium, i.e., not all rural residents will migrate to the urban sector and not all urban residents will migrate to the rural sector, even though expected-value differences between two regions are present.

Our model context is the one in which a worker, born with a type y, chooses a sector to live in. That means, more highly skilled workers are more likely to be found in the urban areas while low skill workers in the other. Thus in equilibrium, there is a productivity threshold level for rural residents y^M at which the worker y^M is indifferent between the city and the countryside. Similarly for urban residents, a productivity threshold level y^C can also be identified. These two cutoff productivities must satisfy:

$$rA(y^M) + Z = rS^M(y^M), \tag{2.3}$$

$$rA(y^C) + Z = rS^C(y^C). \tag{2.4}$$

Eqs. (2.3) & (2.4) are the so-called no-migration (or no-arbitrage) conditions. Since $rA(y) = y_a$ for every y, this implies that $S^M(y^M) = S^C(y^C)$. The flow values and the Nash bargaining wage given in the two previous sections allow us to write explicitly the flow values of a urban unemployed worker for each Hukou status as follows:

$$\begin{aligned} rS^M(y) &= \tfrac{f(\theta)y_0}{r+s+h+f(\theta)} \qquad \text{if } A_1 y \geq y_0; \quad 0 \text{ otherwise,} \\ rS^C(y) &= \tfrac{(r+s)b+\beta f(\theta)A_1 y}{r+s+\beta f(\theta)}. \end{aligned}$$

In equilibrium, $S^M(y)$ cannot be equal to zero because otherwise there will be no rural residents living in the city. Hence, the cutoff productivity y^C is determined by equalizing $S^M(y) = S^C(y)$ which yields

$$y^C = \frac{r + s + \beta f(\theta)}{r + s + h + f(\theta)} \times \frac{y_0}{\beta A_1} - \frac{(r+s)b}{\beta f(\theta) A_1} \tag{2.5}$$

The second cutoff productivity y^M is obtained from Eq. (2.1). In fact, the number of residents working in the rural sector is $N_a = N_a^M + N_a^C = NG(y^M) + (1 - N)G(y^C) = Ny^M + (1-N)y^C$, implying that

$$y^M = \frac{\left(\frac{rS^M - Z}{A_a}\right)^{\frac{1}{\phi-1}} - (1-N)y^C}{N}, \tag{2.6}$$

where $S^M = S^M(y)$ which is shown to be independent of type y. In equilibrium, it is expected that $y^M > y^C$ because otherwise some urban Hukou holders who are more skilled than some rural migrants are found to be in the rural sector. Obviously, this case does not make sense. As Eq. (2.6) shows a negative relationship between y_M and y_C, meaning that more urban Hukou holders deciding to move to the rural sector is associated with less illegal migrants in the urban sector since this sector is not attractive to live in.

2.3.5 Labor market equilibrium

Before closing the model by defining a urban labor market equilibrium, one needs to find the free condition. Since entry is costless but urban firms pay search costs to fill vacant positions, the free entry drives J_v to zero. Substitutions give:

$$\frac{c}{q(\theta)} = p \int_{y^M} [J^M(y)] g_u^M(y) dy + (1-p) \int_{y^C} J^C(y) g_u^C(y) dy, \tag{2.7}$$

where $g_u^i(y)$ is the distribution of type among the unemployed workers for each Hukou status for $i = \{C, M\}$. This is because on-the-job-search is excluded and only unemployed workers may fill vacancies. Bayes' Law allows that

$$g_u^i(y) = \frac{u^i(y)}{u^i} g^i(y)$$

where $u^i(y)$ is the unemployment share of type y and $u^i = \frac{\int_{y^i} u^i(y) dG^i(y)}{1 - G^i(y^i)}$ is the unemployment rate for $i = \{C, M\}$. Let $e^i(y)$ be the steady-state employment share of type y in the urban area respectively for $i = \{C, M\}$, it follows that $u^i(y) + e^i(y) = 1$. In steady-state equilibrium, the flows into and out of unemployment should be equal, so that

$$\begin{aligned}
(s+h)e^M(y) &= f(\theta)u^M(y) \Rightarrow u^M(y) = \tfrac{s+h}{s+h+f(\theta)}, \\
se^C(y) &= f(\theta)u^C(y) \Rightarrow u^C(y) = \tfrac{s}{s+f(\theta)}.
\end{aligned}$$

The total mass of urban unemployed workers is obtained by aggregating across the population

$$U = U^M + U^C = N \int_{y^M} u^M(y) dG^M(y) + (1 - N) \int_{y^C} u^C(y) dG^C(y),$$

and the urban unemployment rate is

$$u = \frac{U}{1 - N_a}.$$

Let define a labor market equilibrium as below:

Definition: A urban labor market equilibrium consists of a triple (y^C, y^M, θ) satisfying the two cutoff-productivity equations (2.5) and (2.6) and the free entry condition (2.7).

Given that, one could proceed to study the effects of labor market policy on its outcome. We are particularly interested in analysing how the Hukou law affects the urban unemployment rate and the social welfare. Let define a social welfare function by the sum of the utilities of the employed and the unemployed, the production of the firms net of search costs as follows:

$$SW = N_a y_a + E^M \int_{y^M} A_1 y dy + E^C \int_{y^C} A_1 y dy + U^C b - \theta U c.$$

The first term in the social welfare function represents the total agriculture output produced by N_a workers (the sum of rural Hukou stayers (N_a^C) and a proportion of urban Hukou migrants (N_a^M). The second and the third term are the total production both illegal and legal urban employed workers produce. Note that the total labor costs are cancelled out because these costs are directly transferred from the urban firms to the urban employed workers. The fourth is the benefits that only legal workers in the urban areas can obtain from the government. And the last term is the total costs of filling V $(= \theta U)$ vacant positions.

2.4 Numerical analysis

The numerical analysis is based on a comparison of steady states. The model parameters are calibrated based mainly on the data provided by the Chinese Household Income Project (CHIP) and the 2007 OECD Employment Outlook. The first, a Chinese household survey which was constructed for only two years, 1995 and 2002, contains mainly information on both rural and urban individual income. In 1995, the CHIP conducted a survey of 7998 rural households (with 34739 individuals) in 19 provinces plus 6931 urban households (with 21,698 members) in 11 provinces. In 2002, the survey was conducted with a bit larger sample of rural and urban individuals with an extent to provide information on about

5327 rural-urban migrants.

In China, the official urban unemployment rates reported annually by the Chinese National Bureau of Statistics remain around 4%. The unemployed category excluded many workers since these numbers comprised large proportions of workers laid-off from the SOEs; certain workers forced into early retirement before their official retirement age (60 for men and 58 for women) who may be seeking work but are denied registration at public employment offices; rural migrants, school-leavers and first market entrants looking for jobs. Data on unemployment in developing countries has proven to be of poor quality. For this reason, we use the 2007 OECD Employment Outlook, a dataset contains information for three sectors: rural, informal and formal. We refer to informal (formal) job defined by OECD as the job occupied by illegal (legal) workers to calibrate the share of rural Hukou holders and the unofficial unemployment rate, though doing so is not ideal.

2.4.1 Calibration strategy

The model parameters are then calibrated on an annual basis with the list comprises: $(N, A_a, A_1, \phi, \mu, \eta, r, b, s, h, y_0, Z, \beta)$. Particularly, the year chosen for calibration is 2002. For a summary of how these parameters are computed, see Table 2.1.

As observed, the annual China interest rate is $r = 0.0531$. We base on 2007 OECD Employment Outlook's estimation, which is based on the 2000 China Population Census, to calculate the proportion of workers who are legal rural residents. In the OECD report for 2000, about 82 millions people are in the category of informal employment which is defined as the difference between the official total employment figures and urban registered employment. According to OECD, those 82 millions people composed mainly of i) rural migrant workers who because of the

Hukou registration system could not work in registered enterprises; and ii) laid-off workers from state enterprises who took informal employment on a temporary basis while remaining nominally attached to their previous work units in order to obtain welfare benefits and re-employment opportunities. With the 2000 level of rural employment level of about 489 millions and a total labor force of 741 in the same year, the proportion of workers who are obliged to stay in the rural sector N is about 72%. Since 2002 is the year for calibrating the model parameters, the extrapolation allow us to set $N = 70\%$ for 2002.

The following parameters can be computed directly from the 2002 CHIP data set: (b, y_0, s). First, the 2002 CHIP questionnaire asked urban individuals about their income, benefits and unemployment duration. From this sample, we extract only those workers who are currently employed, and for those reporting permanent and long-term contracts, the average annual net wage they declared is about 11,200 yuan. Those with no employment contracts earned about 8,000 yuan per year, hence we set $y_0 = 8,000$. Given that only small number of sample's respondents receiving unemployment income and their relatively small earned income, we set $b = 0$.

The output elasticity of employment in the rural sector $\phi = 0.11$ is from Fan and Pardey (1997) who estimate this parameter from a panel data of set of seven regional agricultural productions during the 1965-1993. The remaining parameters $(A_a, A_1, M, \phi, h, c)$ are computed as follow. The 2002 CHIP provides information about rural income per capita, 3700 yuan, and the share of rural employment in the labor force obtained from the OECD Employment Outlook, 63%. Through applying Eq. (2.1) we can calculate A_a and hence $A_a = 2500$ yuan.

We follow Rickne (2010) who uses firm-level data conducted by the China National Bureau of Statistics covering all the SOEs and all other enterprises for which annual sales were above 5 million yuans. She reports the distributions of regional unemployment and vacancy rates for the 2001-2005 period, and from her sample we can compute the labor market tightness for 2002. The result is of about 2.14. Following the literature on search models applied to developing countries context, we set worker's bargaining power at $\beta = 0.5$, and the matching elasticity $\eta = \beta$ to satisfy the Hosios efficiency condition. Given the 2002 CHIP survey questioned urban individuals on their unemployment spell and among employed workers with permanent contracts, 3.81 month is the average duration. Thus $\frac{1}{f(\theta)} = \frac{12}{3.81}$ annually. Given $\beta = \eta = 0.5$ and $\theta = 2.14$, the matching efficiency is then $\mu = f(\theta)/\theta^{1-\eta} = 2.15$.

Official unemployment rate in the urban areas reported by the Chinese government is 4% yearly so that we choose the rate at which an urban Hukou worker looses his job is $s = 0.13$. That implies that legal job lasts about 7.9 years which is consistent with the 2002 CHIP survey that provides information on employment spell of urban workers with permanent contract. A long employment period might be associated with certain government policies applied by China's Communist Party regarding workers in the SOEs. Another reason might be that SOE workers would prefer to stay and benefit from social programs rather than move to the private sector, due to the weak employment protection available to the latter.

We chose the technology parameter A_1 and the separation rate that captures the Hukou enforcement in the urban area h to target the 2002 total unemployment rate of about 8% provided by OECD and the 2002 average urban income of 11,200 yuan calculated from the CHIP 2002. From the labor market equilibrium, we can compute the average wage a urban Hukou worker could get

$$E(w) = \int_{y^C}^{1} w(y) \frac{e^C(y)}{e^C} g(y) dy,$$

where $w(y)$ is the Nash bargaining solution given by (2.2) and $\frac{e^C(y)}{e^C}g(y)$ reflects the distribution of type among the urban Hukou employed. By solving the system of the urban unemployment rate equation and the above average wage equation, we obtained $A_1 \approx 26,000$ yuan and $h = 0.35$.

Given $s = 0.13$ as calibrated above, the average employment duration for an illegal worker is then $\frac{1}{s+h} = 2.08$ years. This job duration roughly corresponds to the average estimate provided by Knight and Yueh (2004) for Chinese rural migrants in 2000 (2.2 years) who work in the urban sector. Our calibration suggests that a legal job lasts about six times longer than an illegal job.

To compute the migration costs we use the rural-urban no-migration condition (2.3) which leads to $Z = 3,200$ yuan. As a standard procedure for pinning down the labor market tightness value, we chose $c = 8,020$ yuan. The next section provides our quantitative results based on the baseline parameters.

2.4.2 Simulation results

The effects of relaxing the Hukou law

We start by computing the model equilibrium for the baseline case, following the parameterization established in the previous section. The equilibrium values are reported in first column of Table 2.2 where the market tightness, the urban legal and total unemployment rate are targeted. The value equilibrium value of y^M indicates that among the rural Hukou holders (accounts for 70% of the total labor force), 77% of them stay in the countryside while at the same time the rest of them, 23% decides to move to the city areas without urban Hukou permit. Similarly, among the urban Hukou holders (30% of the total labor force), 30% of them moves to the countryside while 70% stays in the city. Note that the condition requires

Table 2.1 Annual parameters

Parameter	Meaning	Source/target
$r = 0.0513$	interest rate	National Bureau of Statistics of China
$b = 0$	unemployment income	2002 CHIP data
$y_0 = 8,000$ yuan	mean wage for no-contract workers income	2002 CHIP data
$A_a = 2,500$ yuan	rural prod. technology	rural income per capita
$A_1 = 26,000$ yuan	urban prod. technology	mean wage for permanent contracts
$Z = 3,200$ yuan	migration cost	No-migration condition
$s = 0.13$	job separation rate for urban Hukou	official unemployment rate
$\beta = 0.5$	worker's bargaining power	Albrecht et al. (2009)
$\eta = 0.5$	unemployment elasticity	Hosios' efficient condition
$\phi = 0.11$	rural labor elasticity	Fan and Pardey (1997)
$h = 0.35$	law's enforcement	urban unemployment rate
$\mu = 2.15$	matching efficiency	
$c = 8,020$ yuan	vacancy cost	mean tightness
$1/f(\theta) = 3.81$ months	urban unemployment spell	2002 CHIP data
$E(w) = 11,200$ yuan	average wage of legal workers	2002 CHIP data
$u = 8\%$	urban unemployment rate	OECD Employment Outlook 2007
$\overline{\theta} = 2.14$	mean tightness	Rickne (2010)
$N_a = 63\%$	2002 rural employment share	OECD Employment Outlook 2007

a rural Hukou worker being hired by urban firms is his productivity is at least as high as $y0/A1 = 0.31$. The value $y^M = 0.77$ satisfies this condition. However, $y^C < y0/A1$ meaning that firms hiring legal workers whose productivity is low still gain positive match surplus.

Consider now the effects of relaxing the Hukou law by decreasing either the law enforcement h or the number of rural Hukou residents N. First, keeping $N = 70\%$ while reducing h from the baseline case until $h = 0$. This is shown in the left part of Table 2.2. As the law's enforcement is relaxed, the share of the rural resident going to move to the city increases substantially from 23% to 45% if the law is completely removed. The share of urban Hukou holders going to move to the countryside slightly decreases from 30% to 32%, reflecting the fact that urban-sector firms would benefit more from hiring illegal workers and thus creating disadvantage for legal urban residents. The part of the labor force decides to locate in the rural sector therefore decreases with the relaxation of the law's enforcement.

The most interesting result in this exercise however is the increase in labor market tightness, and this is explained below. Relaxing the law has two simultaneous effects. First, it makes the urban sector more attractive to rural workers, making the flood of rural-urban migrants. Second, the rent urban firms extract from illegal workers is higher than that from legal workers because the wage paid to illegal workers is fixed so that, according to Pissarides (2000), firms would naturally respond by posting more vacancies per unemployed. The total positive effect on job creation ($\theta \uparrow$) reflects the fact that the increase in the number of vacant positions appears to be more important than the increase in the number of unemployed. As a result, the average wage of an employed worker who holds the urban Hukou status rises.

The last row of the first part shows an interesting result where the value of the social welfare is negatively correlated with h. This is largely due to the substantial increase in the number of illegal hires that dominates the fall of legal hires with the total cost of filling V vacant positions.

An alternative choice for the Chinese Government to relax the Hukou law is to allow more rural residents to establish their life in the urban sector. The first and fourth column of Table 2.2 show the effect of decreasing N from 70% to 60% while keeping the law enforcement $h = 0.35$ unchanged. The growth of legal residents in the urban sector creates a sort of congestion effect, pushing certain urban legal residents into the rural sector as y^C increases and retaining legal rural residents as y^M also increases. In this case, the number of persons working in the rural sector

Table 2.2 Simulation results

	$N = 70\%$			$N = 60\%$		
	Baseline h=0.35	h=0.2	h=0	h=0.35	h=0.2	h=0
Tightness θ	2.14	7.58	23.8	1.14	4.15	13.7
Share of rural Hukou y^M	0.77	0.61	0.55	0.98	0.70	0.59
Share of no rural Hukou y^C	0.30	0.31	0.32	0.29	0.31	0.32
Share of rural labor force N_a	0.63	0.52	0.48	0.71	0.55	0.49
Urban illegal unemployment rate u^M	0.13	0.053	0.012	0.173	0.07	0.016
Urban legal unemployment rate u^C	0.04	0.022	0.012	0.054	0.029	0.016
Urban unemployment rate u	0.08	0.039	0.012	0.059	0.045	0.016
Ave. wage of legal workers $E(w)$	11,200	11,390	11,485	11,052	11,280	11,410
Social welfare SW	4,972	5,622	6,261	5,417	5,886	6,516

goes from 63% (baseline case) up to 70% ($0.98 \times 0.6 + 0.29 \times 0.4$). This congestion effect might explain why both labor market tightness and urban unemployment rate fall. Interestingly, the substantial rise in rural labor force, though decreases the average wage earned by legal urban employed, increases the social welfare.

Comparing the second and the fifth column ($h = 0.2$) or the third and the sixth ($h = 0$) tells us that allowing more urban Hukou holders would only increase the urban unemployment rate if the law enforcement in the urban areas is relaxed. If N is kept at 60%, the interpretation of the right part of Table 2.2 is similar to the left.

Unemployment insurance

As a result of the SOE reforms implemented in the early 1980s, many workers found themselves without employment. Thus in 1986 the Chinese government launched an unemployment benefit program, known as Interim Provisions on Unemployment Insurance of Staff of State Enterprises (Interim Provisions), which was intended to cover the basic needs of temporarily unemployed workers. Under this new program, all staff contributions were set at 1% of total payroll, yet coverage granted to a limited number of SOE staff categories only (see Lee (2000))). From 1993 to 1999, coverage was extended to three more SOE staff categories. The most recent UI program was reformed in 1999 and the basis of the system in effect today where in the urban areas firms in all ownership sectors are required to provide UI coverage to their employees (see Rickne (2010)). This system is financed by firm contributions amounting to about 2% of total payroll, and from workers who contribute 1% of their wages. The benefit level is set by governments of provinces, autonomous regions and municipalities at a level in between the minimum wage and the minimum living standard of urban residents. It is not primarily calculated based on earnings, but on the total period of continuously paid contributions. As such, the income protection of the program is low, representing a replacement rate of 14.7% in 2005.

According to the Director General of the China's Institute for Labor Study of the Ministry of Human Resources and Social Security - You Jun - setting up the unemployment insurance system was a historic choice for China. Although it guaranteed the basic livelihood of the unemployed and maintained the social stability, it provides a weak role in promoting re-employment.

For this exercise we investigate how labor market outcomes react to this increase in unemployment insurance. As mentioned in the calibration strategy section concerning the value of b, the number of people receiving unemployment income in the 2002 CHIP survey is relatively small compared to sample observations, and the income they get from it is also very small. We calculate the replacement rate by dividing the unemployment benefits b by legal workers' average wage $E(w)$, and then reported the effects of varying the replacement rate from 10% to 50% in Table 2.3.

Table 2.3 Effects of rising replacement rate

	$N = 70\%$			
	Baseline $b = 0$	$b = 10\%E(w)$	$b = 30\%E(w)$	$b = 50\%E(w)$
Tightness θ	2.14	1.80	2.03	2.25
Share of rural Hukou y^M	0.77	0.80	0.78	0.77
Share of no rural Hukou y^C	0.30	0.30	0.30	0.30
Share of rural labor force N_a	0.63	0.649	0.637	0.627
Urban illegal unemployment rate u^M	0.13	0.143	0.135	0.129
Urban legal unemployment rate u^C	0.04	0.043	0.041	0.04
Urban unemployment rate u	0.08	0.083	0.081	0.078
Ave. wage of legal workers $E(w)$	11,200	11,261	11,446	11,612
Social welfare SW	4,972	4,935	5,028	5,107

Overall, rising unemployment benefits is found to have little effect on labor market outcomes and social welfare. It has both direct and indirect effects on job creation. First the direct effect results from reductions in the total surplus of a legal match and therefore firms have less incentive to hire legal workers. Second, the indirect effect is a by-product of the improvement in the quality of the illegal workers ($y^M \uparrow$). The decrease (increase) in θ when benefits increase to is a result of the direct (indirect) effect governing the indirect (direct) effect.

Technological change

In this exercise we study how the equilibrium reacts to changes in aggregate productivity A_1. Results are reported in Table 2.4. An increase in production technology implies higher employment in the urban sector since both y^C and y^M decrease, higher probability of finding urban job and therefore lower urban unemployment rate. The intuition is that improvement in production technology make legal worker's outside options less attractive, and alternatively, more rural migrants will search for urban sector opportunities. The average quality of

Table 2.4 Effects of increase in production technology

	$N = 70\%$			
	Baseline $A1 = 26,000$	$A1 \uparrow$ by 1%	$A1 \uparrow$ by 5%	$A1 \uparrow$ by 10%
Tightness θ	2.14	2.33	2.97	3.70
Share of rural Hukou y^M	0.77	0.76	0.74	0.72
Share of no rural Hukou y^C	0.30	0.29	0.28	0.27
Share of rural labor force N_a	0.63	0.623	0.603	0.587
Urban illegal unemployment rate u^M	0.13	0.128	0.115	0.104
Urban legal unemployment rate u^C	0.04	0.038	0.034	0.031
Urban unemployment rate u	0.08	0.077	0.071	0.065
Ave. wage of legal workers $E(w)$	11,200	11,373	11,965	12,683
Social welfare SW	4,972	5,042	5,277	5,538

labor supply is worsening, making urban sector firms less incentive to create jobs. Simultaneously, higher aggregate productivity increases a firm's surplus and thus more job creation takes place. The rise in θ suggests that the change in aggregate productivity governs the change in average skill level. Even for small variation in the market tightness, both wage of legal workers and social welfare increase substantially following a positive aggregate productivity shock.

2.5 Conclusion

We started building the model based on the study by Laing et al. (2005) on how the Hukou household registration system impacts the Chinese urban unemployment rate through migration channel. We then incorporated their model in the worker heterogeneity environment introduced by Albrecht et al. (2009). Our model is typically not a behavioral model of migration as the classical Harris-Todaro model in the sense that even though expected-income differences between rural and urban areas exist, there should be no migration in equilibrium due to labor market friction and turnover in the urban areas, making migration decision costly. Our main finding is that the relaxation of the Hukou law itself by either decreasing the law enforcement or allowing more people to live in the city or both at the same time resulted in a lower unemployment in the urban sector.

While Laing et al. (2005) resulted in a claim that relaxing the law's enforcement would imply an increase in urban unemployment rate and make it difficult to find jobs in the urban sector, our finding showed the opposite. This is due to the fact that the labor market's openness for illegal workers would encourage them to join this market and put less pressure on the principal market for legal workers. From a policy perspective, China is certainly facing many challenges in terms of growth in informal employment and large formal-informal flow and high urban unemployment rate. To deal with this problem, our study suggests that a relevant policy should be adapted to abolish the Hukou system.

CHAPTER III

FRICTIONAL WAGE DISPERSION AND THE ROLE OF ASYMMETRIC INFORMATION

This paper aims to explain why worker having similar characteristics are paid differently through applying a search model with asymmetric information. The reason is through possessing private information, both firms and workers will make only modest wage offers to avoid separation, a mechanism that disperses the wage distribution.

Keywords: mean-min ratio, asymmetric information, take-it-or-leave-it offers

3.1 Introduction

Why are similar workers paid differently? For a long time, this question has attracted numerous theorists to provide a convincing theory of wage dispersion (Mortensen (2003)). A recent work by Hornstein et al. (2007) finds that the amount of wage dispersion derived from numerous classes of search models is relatively small as compared to that found in the data. They refer to wage dispersion as frictional wage dispersion and define a direct measure called the mean-min ratio, i.e., the average wage divided by the reservation wage. According to the authors, an ideal empirical estimate of the frictional wage dispersion "requires the empirical distribution of wages for identical workers employed in the same narrowly defined labor market"; and because of measurement errors and incomplete information often presented in individual surveys, "the most common measures are estimates of residual wage dispersion from a Mincerian wage regression with as many control variables as possible". Empirical research has shown that observable worker characteristics such as education, experience, age, gender, occupation, etc can only explain up to 30 percent of the wage variation. The remaining unobservable (unexplained) accounts for 70 percent and is often referred to the residual wage dispersion. A mean-min ratio based on residual inequality therefore represents upper bounds for actual frictional wage dispersion.

The key fact that explains the failure of the standard model in amplifying frictional wage dispersion is the high value of non-market time during unemployment in the data. Because in general workers are impatient in getting a job so they may forgo higher wage opportunities if they were waiting longer for them. Alternatively, if search cost efforts are very high then unemployed workers become extremely impatient then they are willing to reduce their reservation wage, which in turn rises wage dispersion. According to Hornstein et al. (2007)'s calibration for the US and Europe, the value of non-market time must be implausibly low (negative indeed) in order to bring the model prediction closer to the data. Hornstein et al. (2007) also examine four class of search models including (i) imperfect correlation between job values and initial wage; (ii) risk aversion; (iii) directed search; and (iv) on-the-job search, and find that the most promising direction is on-the-job-search models but it still needs substantial improvements.

The approach taken in this paper is different from those suggested by Hornstein et al. (2007), that inspired by Delacroix and Wasmer (2006)'s two-side asymmetric information model with the take-it-or-leave-it bilateral bargaining to address whether this kind of mechanism can explain frictional wage dispersion. Delacroix and Wasmer introduce asymmetric information model to differentiate the destinations for worker outflows from employment, the quit and layoff to unemployment and the job-to-job flows, and then compare these flows between Europe and the U.S. The model presented in this paper differs from theirs in the following characteristics: neither on-the-job search nor firing costs nor investment in human capital is designed for the model.

We find that under plausible parameters, the model is able to reach closely the amount of wage dispersion found in the Current Population Survey. The intuition is that in a take-it-or-leave-it offer environment, one party has to take into account of the private information the other party possesses. For example when a firm makes an offer, it does not know in advance the offer is accepted for sure. Indeed a firm posting vacancies must take expectation over a worker's private values. Because the firm knows its own productivity value so that it will make an generous offer if its productivity is high as to avoid the offer rejected. The same principle applies to the case where workers make offer but in the inverse sense. In other words, workers with high utility from employment make modest offers or low wages. As a result, accepted wages must be a subset of offered wages and the mechanism described here helps to understand why dispersion exists among workers with similar characteristics. Our results are consistent with the empirical work by Abowd et al. (1998) that studies a panel data of over one million French workers from more that five hundred thousand employing firms. The authors find that more productive firms pay higher wages after controlling for person effects and worker heterogeneity after controlling for firm effects also provides an important source of wage differentials within an industry.

The idea that asymmetric information generates wage dispersion is credited to Burdett and Judd (1983)'s work. In their model, sellers do not know how many other offers their potential buyers may have, which discourages them from demanding the highest possible price. With sellers playing the workers' role, the argument is obviously similar to our framework.

Mortensen (2003) argues that wage dispersion in the context of Burdett and Judd (1983) should reflect productivity dispersion in the sense that more productive employers offer higher pay to attract and retain more workers. Friction and turnover presented in labor market however prevent workers flow from less productive to more productive employers. But productivity dispersion itself is not enough as shown by Hornstein et al. (2007). It seems that the standard model is missing at least one element. Abowd et al. (1998) find that worker heterogeneity after controlling for observed characteristics provides a more important source of wage variation in France than firm heterogeneity. For this reason, utility dispersion among unemployed workers is an additional source of heterogeneity in our model. If worker's utility from employment is high enough then he may want to lower his reservation wage.

In Section 3.2, we try to estimate a measure of frictional wage dispersion. Section 3.3 examines the failure of search models in explaining frictional wage dispersion. Section 3.4 describes the model. In section 3.5, a calibration exercise is carried out and the model's results are produced. Section 3.6 draws some conclusions.

3.2 Residual wage dispersion as an estimate of frictional wage dispersion

Since frictional wage dispersion reflects wage dispersion for ex ante homogenous workers, to estimate it from microdata, one should control for as many variables as possible. This quite difficult given the available information provided by individual surveys. We estimate residual wage dispersion throughout the CPS March Supplement and refer to residual wage dispersion as frictional wage dispersion.

Because the CPS raw data contains various types of information and the questionnaires have changed over time, the Integrated Public Use Microdata Series of the March Current Population Survey (IPUMS-CPS), a friendlier version of the CPS, will be applied. Indeed, supplemental inquiries on special topics were added for particular months, and to make data more compatible, the IPUMS-CPS harmonizes the CPS raw data to produce a consistent and user-friendly version for 1962 to 2008. Unfortunately, some important variables needed in our analysis, such as hourly wage or union membership, are only available from 1990 onward. We therefore consider only the period 1990-2008. To minimize measurement error bias, we restrict the sample to civilian adults (children and Armed Forces members are all dropped) who are currently employed in the non-farm sector. We then drop individuals who are currently in school, self-employed and unpaid worker, and whose hourly wage are top-coded ($99.99 an hour or more) or falls below the federal minimum 1983-dollar real wage ($3.35).

We follow Hornstein et al. (2007) to consider the mean-min ratio as a measure of frictional wage dispersion. This ratio has not acquired its popularity but has been proved to satisfy the five standard axioms for "ideal" inequality index discussed in Cowell (2000): anonymity; the population principle; scale invariance; the principle of transfers; and decomposability. Moreover, the mean-min ratio also has similar properties as the 90th - 10th percentile ratio. Analytically, the mean-min ratio is the most relevant wage dispersion measure for the class of search models because the worker's outside option determines the lowest wage paid while the average wage can easily be computed as wage generally follows a particular distribution function. Within the framework of search models, the mean-min ratio is the most relevant wage dispersion measure, as the worker's outside option determines the lowest wage paid while the average wage can easily be computed, given that wage generally follows a particular distribution function.

For each every year during the 1990-2008 period, we run an OLS regression for the Mincerian equation

$$w_{it} = \hat{\alpha}_t X_{it}^{'} + \xi_{it},$$

where w_{it} is the log of hourly real wage for individual i in year t, α_t is a vector of estimated coefficients for year t and ξ_{it} represents individuals' unobservable characteristics. The vector controlling the observed factors, X_{it}, represents:

- 5 education dummies (high school dropouts, high school graduates , some college, college graduates and postgraduates),
- a linear and a quadratic term in experience (age-years of education-6)[1] to allow for nonlinear effects,
- a dummy for gender,
- a dummy for marital status,
- a dummy for union status,
- 3 race dummies (white, black, other),
- 4 regional dummies (Northeast, Midwest, South, West),
- and 3 occupation dummies (managerial & professional, white collar, and blue collar).

On average, these year-by-year regressions yield an R^2 of around 0.35, a value commonly agreed upon within empirical analysis on Mincerian wage regressions,

[1] Note that years of schooling were not reported in the data after 1991. To be used appropriately, this variable should then be recoded. For example Eckstein and Nagypal (2004) assign 10, 12, 14, 16, 18 to years of education, varying from high school dropouts to postgraduates respectively.

as observed characteristics can explain at most 1/3 of the total wage variation. In other words, 65% of the wage dispersion is left unexplained and any estimates of the residual wage dispersion represents upper bounds for actual frictional wage dispersion.

A measure of residual wage dispersion across workers is calculated by the following index[2]:

$$\widetilde{w_{it}} = exp(\xi_{it}).$$

Table 3.1 shows a comparison of residual wage dispersion estimates within the IPUMS-CPS data and the PSID data employed by Hornstein et al. (2007). However, as Hornstein et al. (2007) note, information on hourly wages may suffer from measurement error bias so that estimates of min wage should consider the 1st, 5th, and 10th percentiles of the distribution as they are less volatile estimators. Overall, the amount of residual wage dispersion occurring throughout these data are quite large but for an appropriated estimate of frictional wage dispersion, one should refer to the ratio of mean wage to the 5th or the 10th percentile of the distribution.

3.3 Related literature on the mean-min ratio derived from search models

Consider a very simple version of Pissarides (1985) earch model in worker heterogeneity environment described in Hornstein et al. (2007). Let p be the productivity of a match pair and distributed according to a specific cdf $F(p)$ with upper bound

[2]This index is somewhat modified from that defined by Hornstein et al. (2007) although they use panel data by accounting for the movement around a trend of fixed unobserved individual factors .Hornstein et al. (2007) compute an index that is $\widetilde{w_{it}} = exp(\xi_{it} - \overline{\xi}_W e)$ where $\overline{\xi}_W e = \sum_{t=1}^{T} \xi_{it}/T$ for every individual.

Table 3.1 Average mean-min ratio across data

	CPS data	PSID data[a]
Mean-min	4.09	4.5
Mean-1st percentile	2.43	2.8
Mean-5th percentile	1.91	2.1
Mean-10th percentile	1.69	1.75
Observation/year	9,000	2,500
Period	1990-2008	1990-1995
R^2	35-41%	42-45%

[a]Source: Hornstein, Krusell, and Violante (2007).

p^{max}. Employed worker is paid hourly wage $w(p)$, which depends on match productivity, until separation occurs at exogenous rate s while unemployed worker enjoys his non-production income z and is searching for a job.

Let $\bar{w} = E[w|p \geq p_r]$ be the average wage conditional on a match pair where p_r is the lowest productivity level allowed to begin or to continue the production process, and τ the replacement rate once worker and firm separated, i.e., $z = \tau \times \bar{w}$, and the minimum wage paid $w_r = w(p_r)$. If $f^* = f \times [1 - F(p_r)]$ is the job finding rate then, a simple expression for the mean-min ratio is

$$Mm = \frac{\bar{w}}{w_r} = \frac{\frac{f^*}{r+s} + 1}{\frac{f^*}{r+s} + \tau},$$

where r is the risk-free interest rate. Note that all parameters in the mean-min ratio can be computed and this ratio for measuring frictional wage dispersion does not require any information on F. But how large is the Mm ratio?

The standard monthly interest rate is 0.0041. Note that the literature still doesn't reach a consensus on a specific estimate for τ but most of it values are taken from the reasonable range, $[0.2; 0.6]$. If we take the value of monthly job finding rate and separation rate estimated by Shimer (2005a) based on the Bureau of Labor

Statistics data, 0.45 and 0.034 respectively, then the ratio lies in the range:

$$1.03 = \frac{\frac{0.45}{0.0041+0.034}+1}{\frac{0.45}{0.0041+0.34}+0.6} \leq Mm \leq \frac{\frac{0.34}{0.0041+0.034}+1}{\frac{0.45}{0.0041+0.34}+0.2} = 1.07.$$

If we take the value of monthly job finding rate and separation rate estimated by Fallick and Fleischman (2004) based on the Current Population Survey data, 0.283 and 0.013 respectively, then the ratio lies in the range:

$$1.02 \leq Mm \leq 1.05.$$

Both exercises show that the mean-min ratio derived from the basic search models are about twice smaller than that provided by different datasets summarized in Table 3.1. Mechanically, the mean-min ratio is small because the job finding rate largely dominates the sum of separation rate plus interest rate. One can meet the mean-min ratio to the Census estimate (2.20) by lowering the replacement rate τ to -4.3. That is an implausible value. Another possible solution is to reduce $f/(r+s)$ to 0.1, i.e., the job finding is about 10% of the sum of the separation rate and interest rate which is unsupportable by data on worker flows.

Let consider now the class of on-the-job-search model. Intuitively, the ability to search on the job for new employment opportunities makes unemployed workers less demanding, which reduces their reservation wage and allows the model to generate a higher Mm ratio. To see how the mechanic increases the mean-min ratio, consider a slight modification of the basic random matching studied above in which employed workers have possibility of searching for other employers as described in the Burdett and Mortensen (1998) model. They accept to switch job only if they receive any wage offer above their current wage and let f_e be the rate at which an employed worker contacts another employer. The Mm ratio has a new expression

$$Mm = \frac{\frac{f^* - f_e}{r+s+f_e} + 1}{\frac{f^* - f_e}{r+s+f_e} + \tau}.$$

Taking again the above parameter estimates and adding the worker flows from one employer to another also from Fallick and Fleischman (2004), which averaged 2.6% from 1996:1 to 2003:12, the range for Mm ratio now changes to

$$1.06 = \frac{\frac{0.283-0.026}{0.0041+0.013+0.026} + 1}{\frac{0.283-0.026}{0.0041+0.013+0.026} + 0.6} \leq Mm \leq \frac{\frac{0.283-0.026}{0.0041+0.013+0.026} + 1}{\frac{0.283-0.026}{0.0041+0.013+0.026} + 0.2} = 1.13.$$

Comparing to the estimated range without on-the-job search, although the Mm is still far from the empirical one but including on-the-job search in the model significantly improves the result. A more sophisticated on-the-job-search model with endogenous search effort as in Christensen et al. (2005) can closely match the data. To obtain this result, the search cost in their model which makes unemployment unattractive relative to employment must be unrealistically large.

Even in imperfect Bertrand competition model type as in Postel-Vinay and Robin (2002) or Cahuc et al. (2006) where firms are allowed to make counteroffers when there is competition between two employers in contacting a worker, the mean-min ratio exhibits virtually no improvement. Intuitively, counteroffer models may result either in a job-to-job move or in a salary increase on the current job, depending on the choice of the worker. If the cost of job-to-job moving is high enough then the worker may want to continue with his current employer. Therefore, the standard on-the-job search model can only generate little frictional wage dispersion.

Hornstein et al. (2007) also verify the ability of other classes search models such as imperfect correlation between job values and initial wage, risk aversion, and directed search, and conclude that frictional wage dispersion is virtually very small in all of these models.

Recently, Papp (2009) has developed a general equilibrium model with the on-the-job search and the counteroffer bargaining mechanism described in Postel-Vinay and Robin (2002) or Cahuc et al. (2006). In his model, employed workers when switching to another employer face a specific distribution of wage offer that depends on the productivity of their former employers rather than a common wage offer distribution for both employed and unemployed workers. Wage is then mainly dispersed due to the heterogeneity of the firm's productivity. More precisely, higher productivity expands the wage offer distribution to the right because job-to-job transitions always flow from low to high productivity, and better outside offers result in higher wages. His model then closely matches the amount of wage dispersion found in the data.

3.4 Asymmetric information model

3.4.1 Assumption

In the economy, there are an infinite number of firms and an infinite number of workers. All agents are risk-neutral and discount future payoffs at a rate r. Workers may be either employed or unemployed. Firms use only labor input to produce output, according to a constant return to scale technology.

Friction in the labor market does not allow instantaneous meet between firms and workers. When going into business, a firm requires certain resources to post a vacancy and thus attract workers. A worker must spend his time to look for a job. Entry is costless for a firm but a vacant position costs c units of output. Workers and firms meet through a matching function depending on the number of employment vacancies, v, and the current stock of unemployed workers, u,

$$m(u, v) = \mu u^{\eta} v^{1-\eta},$$

where μ measures the matching efficiency and η represents the unemployment share of the total number hired. Define labor market tightness as the ratio of vacancies to unemployment, $\theta = v/u$, then the rate at which an unemployed worker meets a firm is expressed as

$$f(\theta) = \frac{m(u, v)}{u} = \mu \theta^{1-\eta}$$

and the rate at which a firm meets a worker as

$$q(\theta) = \frac{m(u, v)}{v} = \mu \theta^{-\eta}.$$

Upon each matching, the firm-worker pair produces output p, commonly known by both agents and draws upon match-specific utilities. The firm preserves a productivity ϵ while the worker receives an amenity ν. Both ϵ and ν are idiosyncratic shocks, drawn from two specific cumulative distribution functions $F(\epsilon)$ and $G(\nu)$ in their support $[\underline{\epsilon}; \bar{\epsilon}]$ and $[\underline{\nu}; \bar{\nu}]$, respectively. These shocks have a common Poisson arrival rate λ. The assumptions listed below fundamentally determine the bargaining mechanism and constitute the model's key elements.

Assumption 1 *A worker, either employed or unemployed, and a firm bargain over a wage w, by means of take-it-or-leave-it offers.*

Assumption 2 *A firm has a probability β of making an offer w_f to a worker,* *and a worker has a probability* $1-\beta$ *of making an offer* w_w *to a firm.*[3]

Assumption 3 *An employed worker gets involved in the negotiation if a* λ *shock hits him or his employer while an unemployed does so if he receives a job offer.*

Continuing with Assumption A.1, rejecting an offer puts employed workers directly in the unemployment pool and unemployed workers remain there. The model also rule out the possibility for employed workers to switch from one employer to another, and no exiting to an inactive pool takes place.

3.4.2 Steady state values

Let $J(\epsilon)$ and V be the net current values of a matched firm and a vacant firm respectively. J must depend on ϵ, but V does not because in the previous section We have established that only the matched firm-worker pair, and not the vacant one, can generate private shocks. Given the above assumptions, the value functions for both types of firm must satisfy

$$\begin{aligned} rJ(\epsilon) &= p+\epsilon-w+\lambda[EP^{\text{firm}}-J(\epsilon)], && (3.1)\\ rV &= -c+q(\theta)[EP^{\text{firm}}-V_s], && (3.2)\end{aligned}$$

where EP^{firm} is the firm's ex-ante expected surplus resulting from the take-it-or-leave-it offers, defined by

$$EP^{\text{firm}} = (1-\text{prob of separation}) \times E[J(\epsilon)] + \text{prob of separation} \times V. \quad (3.3)$$

[3]One can think of β as the number of offers initiated by firms when firms and workers sit down to negotiate new wages.

For a matched firm, equation (3.1) states that the flow return of being matched - the capital value of being matched times the rate of return on that value - equals the flow profits plus the expected net value resulting from the bargaining process - the Poisson's arrival rate, λ, times the net value, $EP^{\text{firm}} - J(\epsilon)$. Similarly, the flow value of a vacant firm equals the flow cost of posting a vacancy position plus the expected net value resulting from the bargaining process.

The steady state values of a matched worker, $W(\nu)$, and an unemployed worker, U, can be defined in the same way,

$$rW(\nu) = w + \nu + \lambda[EP^{\text{worker}} - W(\nu)], \tag{3.4}$$

$$rU = b + f(\theta)[EP^{\text{worker}} - U], \tag{3.5}$$

where EP^{worker}, similar to equation (3.3), is the worker's ex-ante expected surplus resulting from the negotiation game

$$EP^{\text{worker}} = (1 - \text{prob of separation}) \times E[W(\nu)] + \text{prob of separation} \times U. \tag{3.6}$$

To summarize, an employed worker receives a wage paid w and a match-specific amenity ν while an unemployed enjoys his unemployment insurance b during a job search period.

3.4.3 Job creation condition

Given that the economy has an infinite number of firms and entry is costless, meaning that firms can freely enter into business if V - determined by equation (3.2) - is positive, and otherwise exit. When in equilibrium with a finite number of firms posting vacancies, the net current value of an open vacancy must be zero.

Equivalently,

$$\frac{c}{q(\theta)} = EP^{\text{firm}}. \tag{3.7}$$

Equation (3.7) is called the free entry or the job creation condition. Under an intuitive interpretation, the expected total cost of posting a vacancy - unit cost times the average duration of a vacant position - is equal to the expected benefit of filling it.

3.4.4 Negotiation game and job destruction conditions

According to Assumption A.2, each party's unilateral offer should be differentiated in detail. The negotiation game for a firm is symmetrical with that of a worker, so here We only describe a firm's unilateral offer. Before offering w_f to a worker, a firm must identify the worker's reservation value, ν_r, based on the distribution of his idiosyncratic shocks $G(\nu)$. This reservation value is defined by

$$W(\nu_r) = U. \tag{3.8}$$

That is, at ν_r, a worker is indifferent between being employed and being unemployed. Substitutions give

$$\nu_r = -w_f - \lambda EP^{\text{worker}} + (r + \lambda)U. \tag{3.9}$$

Equation (3.9) provides a negative linear relationship between ν_r and w_f, meaning that the higher the wage offered by a firm, the greater is the chance that the offer will be accepted. Once ν_r has been defined, the firm's optimization problem can be written as follows

$$\max_{w_f}[1 - G(\nu_r)] \times J(\epsilon) + G(\nu_r) \times V$$

subject to (3.9),

where $G(\nu_r) = \Pr[\nu \leq \nu_r]$ thus represents the probability of refusing the firm's offer.

Since all realizations of ν are bounded by its support, the firm's problem can be resolved through an interior solution and two corner solutions. The first corner solution $G(\nu_r) = 1$, i.e., $\nu_r = \bar{\nu}$, must however be ruled out because it would be inconsequential for the firm to offer a wage that is rejected by every worker. The second corner solution $G(\nu_r) = 0$, i.e., $\nu_r = \underline{\nu}$, still exists, as a firm may offer a very high wage that none would refuse. This corner solution is thus

$$w_f^{\text{cor}} = (r + \lambda)U - \lambda E P^{\text{worker}} - \underline{\nu}. \tag{3.10}$$

For the interior solution case, i.e., $0 < G(\nu_r) < 1$, the F.O.C. with respect to w_f is straightforward

$$-G'(\nu_r)\nu_r'(w_f)J(\epsilon) + [1 - G(\nu_r)]\frac{\partial J(\epsilon)}{\partial w_f} = 0. \tag{3.11}$$

This provides an intuitive interpretation: firms choose an optimal wage level by ensuring that the probability of marginal rejection times the firm's surplus equals the expected marginal value of continuation.

Let $g(\nu) = G'(\nu)$ be the density function of ν, the F.O.C. yields an implicit expression for the interior solution

$$w_f^{\text{int}} = p + \epsilon + \lambda E P^{\text{firm}} - H_G[\nu_r(w_f^{\text{int}})]^{-1}, \tag{3.12}$$

where $H_G[\nu_r]$ is the hazard rate of the distribution G evaluated at ν_r. Generally, $H_G[\nu] = \frac{1-G(\nu)}{g(\nu)}$, but we cannot explicitly solve for w_f^{int} unless we specify a distribution function form for G.

Assumption 4 *A worker's match-specific amenity*

(a) *is drawn from an exponential cumulative distribution function, $G(\nu) = 1 - e^{-\gamma(\nu-\underline{\nu})}$, where γ is a parameter, and*

(b) *it has unconditional zero mean, $E[\nu] = 0$.*

Assumption A.4 includes various advantages, thus simplifying our computation. First, 4(a) implies that $H_G(\nu) = \gamma$, which is constant for all ν. Second, 4(b) is equivalent to $\underline{\nu} = -\gamma^{-1}$. Third, the exponential distribution does not have a finite upper bound, $\bar{\nu} = +\infty$, meaning that it is a good reason for excluding the first corner solution. Finally, we arrive at

$$w_f^{\text{int}} = p + \epsilon + \lambda EP^{\text{firm}} - \gamma^{-1}. \tag{3.13}$$

The interior solution is then unique and is an increasing function of ϵ. It is obvious that when ϵ, called the firm's border point, is high enough, the interior solution becomes the corner solution. Denoting this border point as $\hat{\epsilon}$, it takes the following form

$$\hat{\epsilon} = (r + \lambda)U - \lambda EP - p + 2\gamma^{-1}, \tag{3.14}$$

where

$$EP = EP^{\text{firm}} + EP^{\text{worker}} \tag{3.15}$$

is thus the ex-ante expected joint surplus resulting from the negotiation game. Equation (3.14) is called the job destruction condition initiated by workers. Figure 3.1 summarizes the firm's unilateral offer, showing in fact that low productivity firms, $\epsilon < \hat{\epsilon}$, should offer a wage at least as large as the worker's reservation level,

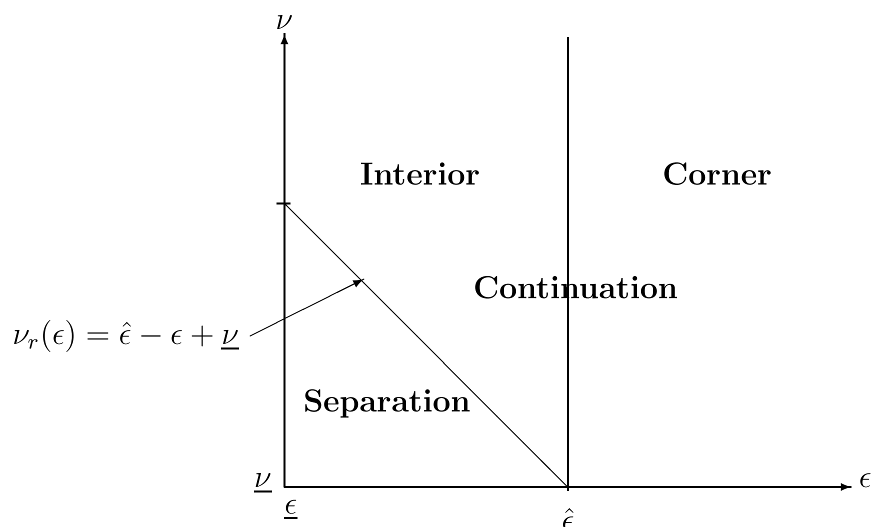

Figure 3.1 Firm's unilateral offer, the case of exponential distribution

$\nu_r(\epsilon) = \hat{\epsilon} - \epsilon + \underline{\nu}$, in order to avoid separation, and that no worker would reject job offers from high productivity firms, $\epsilon \geq \hat{\epsilon}$.

For reason of symmetry, the second job destruction condition initiated by firms can be established as

$$\hat{\nu} = (r + \lambda)U - \lambda EP - p + 2\phi^{-1}. \tag{3.16}$$

To obtain this expression, we also need to assume that ϵ is drawn from an exponential distribution $F(\epsilon) = 1 - e^{-\phi(\epsilon - \underline{\epsilon})}$ with an unconditional zero mean, where ϕ is a positive parameter.

Equilibrium

Definition A labor market equilibrium consists of a quadruple $(\theta, \hat{\epsilon}, \hat{\nu}, U)$ satisfying the job creation condition (3.7); the two job destruction conditions (3.14) & (3.16); and the unemployed value given by (3.5).

In Appendix B.1, we prove that the ex-ante expected surpluses, EP^{firm} and EP^{worker}, are functions of both $\hat{\epsilon}$ and $\hat{\nu}$. Once the equilibrium has been solved, the model provides certain features that differ from corresponding models found in the literature, including: endogenous wage distribution, and two types of separation (quit and layoff to unemployment flows).

Accepted wage set

When combined with wage solutions offered by workers, a complete set of successful wage offers is determined as

$$w = \begin{cases} w_f^{\text{cor}} & \text{if } \epsilon \geq \hat{\epsilon} \\ w_f^{\text{int}} & \text{if } \epsilon < \hat{\epsilon} \ \& \ \nu \geq \nu_r(\epsilon) \\ w_w^{\text{cor}} & \text{if } \nu \geq \hat{\nu} \\ w_w^{\text{int}} & \text{if } \nu < \hat{\nu} \ \& \ \epsilon \geq \epsilon_r(\nu) \end{cases}$$

where w_w^{cor} and w_w^{int} are the corner and the interior solutions resulting from the worker's optimization problem. Depending on the realization of ϵ and ν, it should then be easy to obtain the wage distribution.

Quit and layoff flows

Let Q and L be the probabilities of rejecting job offers initiated by workers and firms respectively. In the firm offer case, Q is thus the separation triangle shown in Figure 3.1, as defined by

$$Q = \int_{\underline{\epsilon}}^{\hat{\epsilon}} \Pr[\nu < \nu_r(\epsilon)] dF(\epsilon) = \int_{\underline{\epsilon}}^{\hat{\epsilon}} G[\nu_r(\epsilon)] dF(\epsilon). \tag{3.17}$$

Similarly,

$$L = \int_{\underline{\nu}}^{\hat{\nu}} \Pr[\epsilon < \epsilon_r(\nu)] dG(\nu) = \int_{\underline{\nu}}^{\hat{\nu}} F[\epsilon_r(\nu)] dG(\nu). \tag{3.18}$$

Appendix B.2 proves that Q is a function of $\hat{\epsilon}$, and L is a function of $\hat{\nu}$. Hence, the quit and layoff to unemployment flows, Q_{EU} and L_{EU}, can be calculated as

$$Q_{\text{EU}} = \lambda \beta Q. \tag{3.19}$$

$$L_{\text{EU}} = \lambda (1 - \beta) L. \tag{3.20}$$

3.5 Numerical analysis

3.5.1 Calibration strategy

The model's parameters are calibrated on a monthly basis. Table 3.2 lists a summary of all our calibration parameters. The aggregate productivity is normalized to 1, without any loss of generality. The standard monthly interest rate selected is $r = 0.0041$, providing a consistent annual U.S. real interest rate of around 5%.

To calibrate the parameters in the matching function, we follow the strategy described in Chapter 1. We set the job finding rate $f(\theta) = \mu\theta^{1-\eta} = 0.594$. We take the elasticity of unemployment with respect to match estimated by Petrongolo and Pissarides (2001), $\eta = 0.5$, for the matching function. We follow Pissarides (2009) to pindown mean market tightness in 1960–2006, which was 0.72, obtained from Job Openings and Labor Turnover Survey (JOLTS) data since December 2000 and the Help-Wanted Index (HWI) adjusted to the JOLTS units of measurement before then. This implied the matching efficiency parameter $\mu = f(\theta)/\theta^{1-\eta} = 2.1$.

The IPUMS-CPS dataset we used in Section 2 to describe wage dispersion also provide data on reasons for unemployment. Among others, these reasons include four choices: (0) not in universe; (1) job loser/on layoff; (2) other job loser; (3) temporary job ended; and (4) job leaver. Information in categories (2) and (3) is not clear enough to be classified, either in the quit-to-unemployment flow or layoff-to-unemployment flow. Since category (0) represents the number of job holders, we refer to the layoff rate as the number of respondents in category (1) divided by those in category (0); and the quit rate as (4)/(0); so that they calculated as percentages of employment. From this classification, the monthly quit rate averages to 0.70, and the layoff rate averages to 1.11. We choose β to target the ratio of quit to layoff flows (0.7/1.11=0.63) which gives $\beta = 0.37$. Given the flows in and out of employment, we set $\lambda = 0.043$ to target the unemployment rate of 5.9%.

The most important issue is the choice of the two parameters used for the exponential distribution of the idiosyncratic shocks, ϕ and γ. We continue to use the IPUMS-CPS dataset to plot the wage density in Figure 3.2. As Mortensen (2003) notes: "Any interesting theory of wage dispersion must be able to explain the shape of as well as the extent of the dispersion in the distribution of wages paid across firms". Two moments of the wage distribution should be therefore taken into account: the skewness and the kurtosis. We define a new measure of skewness - the ratio between the distance from the 10th percentile to the median and the distance from the median to the 90th percentile, $\frac{p50/p10}{p90/p50}$. This measure of skewness is easier for us to draw the shape of wage distribution generated by the model. The resulting skewness $\frac{p50/p10}{p90/p50}$ is 0.96. For the kurtosis, we use the standard formula and obtain a value of 77. We therefore choose a combination of these parameters to fit two wage distribution moments, the skewness and kurtosis, calculated in the previous section. We find one combination, $\phi = 5.5$ and $\gamma = 2.4$, properly suits the two moments, although the kurtosis (4.57) is still far from that shown in the data (77).

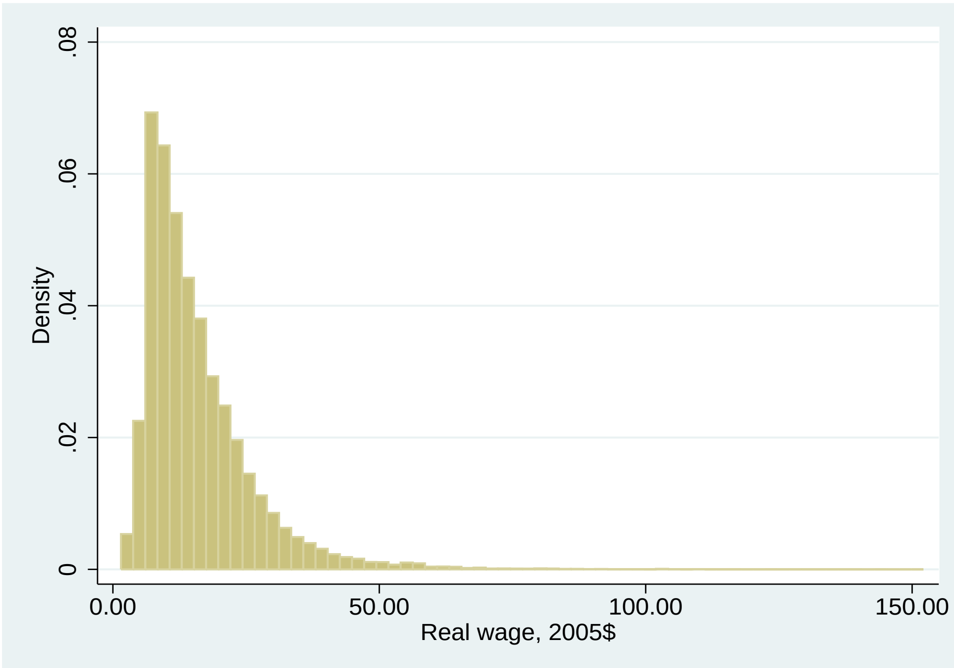

Figure 3.2 Hourly wage (real 2005$ reported individually)

We use the unemployment benefits, $b = 0.6$ as in Chapter 1 and later vary it in an effort to determine how sensitive our model's outcomes. Finally as a standard procedure, we set $c = 0.56$ to pindown the mean tightness $\theta = 0.72$ obtained from Job Openings and Labor Turnover Survey (JOLTS).

The model generated wage distribution is simulated by draw 10,000 exponential random numbers for both the pair (ϵ, ν) and then a proportion β of the draws is used to generate wage observed by firm offer and the rest by worker offer.

3.5.2 Simulation results

We start by computing the model equilibrium in the baseline case, following the parameterization established in the previous section. The model equilibrium values are reported in the first column of Table 3.3. Both $\hat{\epsilon}$ and $\hat{\nu}$ are positive and

Table 3.2 Monthly parameters

Parameter	Meaning	Source/target
$p = 1$	Aggregate productivity	Normalization
$r = 0.0041$	Interest rate	Annual US real interest (5%)
$\lambda = 0.043$	Private shocks' arrival rate	unemployment rate
$\beta = 0.37$	Firm's offer prob.	ratio of quit to layoff flows
$\phi = 5.5$	Parameter in $F(\epsilon)$	Skewness & kurtosis
$\gamma = 2.4$	Parameter in $G(\nu)$	Skewness & kurtosis
$\eta = 0.5$	Unemployment elasticity	Petrongolo and Pissarides (2001)
$\mu = 2.1$	Matching efficiency	Job finding rate
$c = 0.56$	Vacancy cost	mean tightness
$b = 0.6$	Unemployment insurance	Chapter 1

significantly higher than $\underline{\epsilon}$ and $\underline{\nu}$ due to the take-it-or-leave-it bilateral bargaining. Notice that the value of unemployment, $U = 317$, is intrinsically meaningless in the model. What we have to take into account is the net surplus of a worker, $EP^{\text{worker}} - U$. The positive net surplus for both worker and firm reflects the fact that each party accepts the other's offer.

The second part of Table 3.3 reports the model generated four wage dispersion estimators. Comparing to the highest value predicted by the standard model with on-the-job search, the present model provides a better result. The four estimators of wage dispersion significantly increase. Although the resulted mean-min ratio is only half of the level found in the CPS data, the mean-p10 closely matches the data. But as the minimum wages reported by interviews are the subject of criticism as they are volatile, they are often replaced by the 5th and 10th percentiles in the empirical literature.

We also plot the shape of equilibrium wage distribution in Figure 3.3. Compared to the one obtained from the CPS data, drawn in Figure 3.2, the shape generated by the model is quite good, though, the left tail and the kurtosis of the distribution need to be improved.

One of our concerns related to the model result is the chance of refusing an offer is very high as the probability of rejecting an offer stands about 90% in the firm offer case and 83% in the worker offer case. If we compare them with the estimated value based on the NLSY79 data on job offer (21%), then our model generated data are far from the reality. One can think the take-it-or-leave-it offer was responsible for this counterfactural result counteroffer because the possibility of counteroffer was excluded from the model. We could decrease Q or L by only increasing both ϕ and γ at the same time, but this strategy would do more harm than good to the model's wage distribution properties. Indeed, by increasing these parameters, both the firm's and worker's border points $\hat{\epsilon}$ and $\hat{\nu}$ would decrease when applying the two job destruction equations, meaning that there are more firms and workers who would prefer offering corner solutions, thus disturbing the standard shape for wage distribution. In other words, increasing both ϕ and γ would lead higher productivity firms expanding their wage offers to the right, and higher amenity workers expanding their wage offers to the left, thus resulting in a double-peak distribution. Perhaps the model described in this paper only considers two sources of heterogeneity (firm productivity and worker utility) and ignore some other important forms of heterogeneity such as workers may not all enjoy the same unemployment benefits. If so, the probability of refusing an offer is likely to be lower that of the case where all workers have the same income while unemployed.

In section 3.3, we have seen the important role of the unemployment insurance parameter in enhancing the mean-min ratio derived from the standard search models. In this section, we also vary this value from the baseline case, 0.6, to 0.1. The exercise is reported from the second column of Table 3.3 to fifth. Overall, there are littre changes in the four wage dispersion estimators across various un-

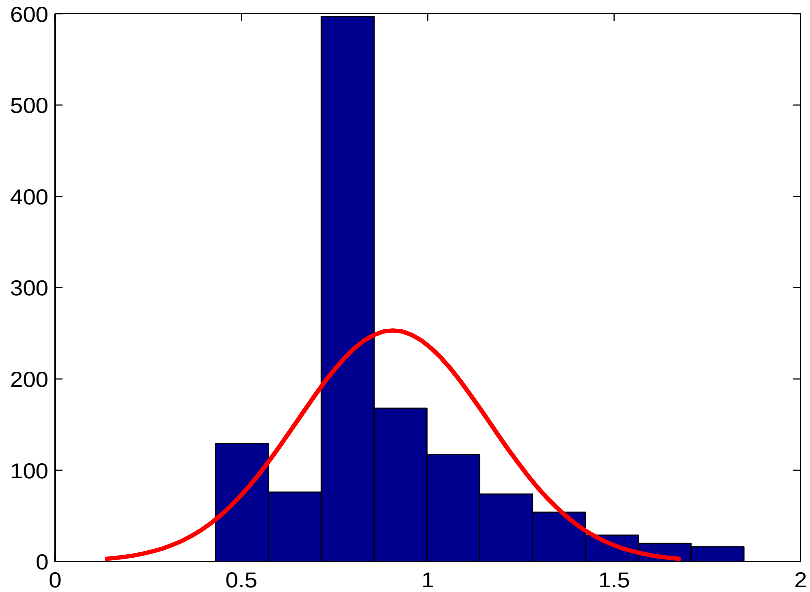

Figure 3.3 Model generated wage distribution

employment income values: the range varies from 2.05 to 2.1 The reason for this can be explained as below.

When the parameter unemployment insurance decreases, a standard result follows: it decreases the worker's outside option (U decreases) and increases the net surplus from a match for both the firm and worker. This in turns lowers both firm and worker's reservation value as translated by the decreases in both $\hat{\epsilon}$ and $\hat{\nu}$ or equivalently the decreases in both Q and L. As a consequence, there are more firms offering high pays and similarly, more workers accepting low wages. One might think that the immediate result should be that cutting unemployment benefits would disperse the distribution of wage while our simulation results show that the dispersion changes moderately. If we look at how wage offers react to change in unemployment insurance illustrated in Figure 3.4, this complementary fact might explains our latter result.

Table 3.3 Equilibrium values & generated wage dispersion

	Baseline[a] $b = 0.6$	$b = 0.4$	$b = 0.3$	$b = 0.2$	$b = 0.1$
$\hat{\epsilon}$	1.05	1.01	0.99	0.97	0.95
$\hat{\nu}$	0.58	0.54	0.52	0.50	0.48
θ	0.72	0.89	0.97	1.06	1.15
U	317	308	305	301	298
Q	0.91	0.90	0.89	0.89	0.88
L	0.84	0.82	0.81	0.81	0.80
$EP^{\text{worker}} - U$	1.18	1.31	1.37	1.43	1.49
$EP^{\text{firm}} - V$	0.68	0.75	0.79	0.82	0.86
mean-min	2.10	2.08	2.05	2.09	2.06
mean-p1	2.06	2.01	1.99	2.02	2.00
mean-p5	1.87	1.76	1.77	1.74	1.76
mean-p10	1.59	1.49	1.53	1.50	1.53
Skewness	0.99	0.97	1.03	0.95	0.99
Kurtosis	4.73	4.67	5.16	4.57	4.6

[a]The labor market tightness, the skewness and the kurtosis of wage distribution are targeted.

Higher unemployment insurance makes high productivity employers (those offering high pay) more generous in their wage offers than low productivity ones as the left part of Figure 3.4 shows a steeper slope of wage as a function of unemployment insurance. This is due to the fact that more productive firms tend to retain their workers. Similarly, the right part of the figure shows that low amenity workers (those requiring high wage) make more wage demands than the high ones. High amenity workers enjoy employment relationship and thus did not want any match breakdown experience even though their outside option has been strengthened. Change in unemployment insurance therefore only changes the shape of wage distribution but not its dispersion.

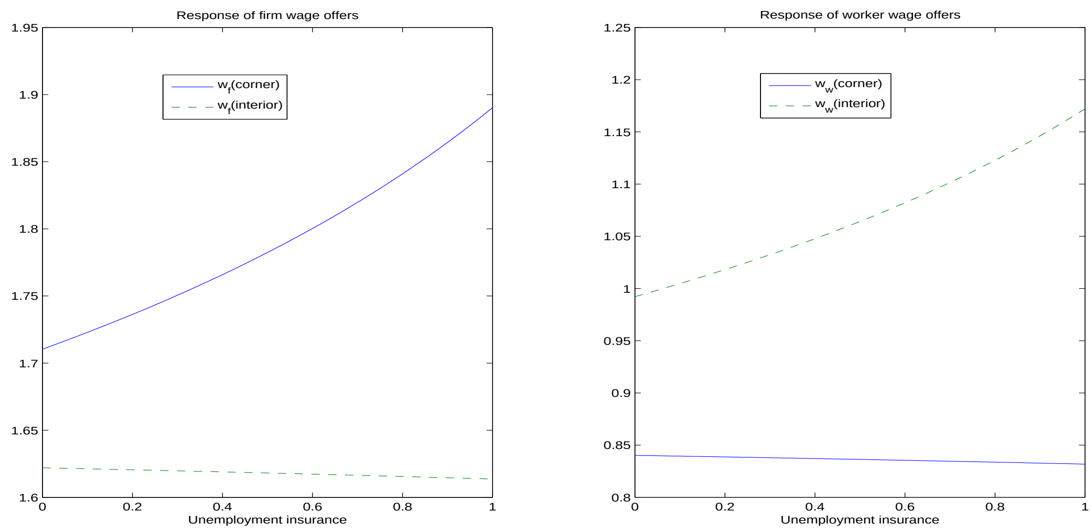

Figure 3.4 Effect of change in unemployment insurance on wage offers

3.6 Conclusion

We have argued in this paper that search theory approach could analytically explain why similar workers are paid differently. In this case, heterogeneous firms becomes the source of wage differences. Quantitatively however, it has been proved to be unable to reach the residual wage dispersion level found in various datasets. If asymmetric information was applied to match-specific productivity for both employer and employee as described in this paper, then this mechanism might improve the ability of standard search models in amplifying frictional wage dispersion, though it does not reach up to the data levels. We have also shown an interesting finding that unemployment insurance, if it was put asymmetric information context, plays almost no role in determining both wage dispersion and unemployment fluctuations. This parameter however has been proved to crucial in both related literatures.

More productive employers offer higher pay to attract and retain more workers.

Similarly, workers with high utility from holding a job (not in the sense of high pay) are willing to offer low wage to stay in the match relationship. Employers that offer low pay and workers who requires high pay learn the lesson that their offers have a chance of being rejected. With the bilateral bargaining mechanic such as take-it-or-leave-it offer, the chance of rejection is even higher. So that both private information about match-productivity and take-it-or-leave-it bargaining helps to understand why some workers are placed in the low end of the wage distribution, while some others with similar characteristics in the high end of the wage distribution. Our results are consistent with the empirical work by Abowd et al. (1998) who find that more productive firms pay higher wages after controlling for person effects and worker heterogeneity explains the majority of wage differentials within an industry.

The asymmetric information is seems to be a realistic hypothesis, the employed bargaining mechanism employed might not however gain its popularity. One might suggest that this kind of wage negotiation can be applied to bad jobs but not every jobs. Wage negotiation for good jobs are often subject to many conditions such as paid vacation, heath insurance or other benefits. In these cases, counteroffer certainly happens and wage can be negotiated not only for one time but also for several times.

One of our results seems to be counterfactural is the unrealistic chance of refusing an offer. We could bring the model result closer to the data but doing so would make the shape of wage distribution deformed.

APPENDIX A

PROOFS AND STOCHASTIC PROCESS IN CHAPTER I

A.1 Proof of equation (1.10)

Omitting the subscript i, denoting the firm's output as a function of L by $F(L) = \frac{p(Y(L))}{P}Y(L)$ and applying the envelope theorem to the firm's value function to get

$$\frac{\partial V(L)}{\partial L} = \frac{1}{1+r}\left[F'(L) - w - w'(L)L + (1-\delta_e)(1-\delta_s)\frac{\partial V(L')}{\partial L'}\right].$$

In the steady state, the required condition is that $L' = L$ so that

$$\frac{\partial V(L)}{\partial L} = \frac{1}{r+\delta}[F'(L) - w - w'(L)L], \tag{A.1}$$

where $F'(L) = \frac{\partial p(Y)/P}{\partial L}Y + \frac{p(Y)}{P}\frac{\partial Y}{\partial L} = \frac{p(Y)}{P}y\frac{\epsilon-1}{\epsilon}$. Inserting (A.1) into the first-order condition with respect to vacancy yields the monopolistic price (1.10).

A.2 Proof of equation (1.12)

Since the Nash solution provides the usual equality $\beta\frac{\partial V(L)}{\partial L} = (1-\beta)(W-U)$ and given (1.9), the flow value of a unemployed worker is given by

$$rU = b + f(\theta)\frac{\beta}{1-\beta}\frac{\kappa}{(1-\delta_e)q(\theta)}. \tag{A.2}$$

Combining the last equation with (1.10) and (A.1) concludes the proof of the wage equation (1.12).

A.3 Proof of equation (1.18)

Following the same procedure as in the case of deterministic productivity, i.e, applying the envelope theorem to the dynamic version of the firm's value function to get

$$\frac{\partial V_y(L)}{\partial L} = \frac{1}{1+r}\left[F_y'(L) - w - w'(L)L + (1-\delta_e)(1-\delta_s)\left(\lambda E_y\frac{\partial V_{y'}(L')}{\partial L'} + (1-\lambda\frac{\partial V_y(L')}{\partial L'})\right)\right].$$

For the sake of simplification, suppose that $\lambda\delta$ is relatively small as compared to λ, then

$$r\frac{\partial V_y(L)}{\partial L} = F_y'(L) - w_y - w_y^{'}(L)L - \delta\frac{\partial V_y(L)}{\partial L} + \lambda\left[E_y\frac{\partial V_{y'}(L)}{\partial L} - \frac{\partial V_y(L)}{\partial L}\right].$$

Given the flow values of a unemployed worker and an employed worker are expressed in section (1.3.5) and the Nash sharing rule $\frac{\partial V_y(L)}{\partial L} = (1-\beta)S_y$, the proof of equation (1.18) is therefore done.

A.4 Stochastic process

To simulate the dynamic version of the present model, consider now the stochastic process by which labor productivity follows as described in Shimer (2005)

$$y = b + e^{x}(y^{*} - b),$$

where y^{*} measures the long-run average productivity, which is equal to 1, and x is an Ornstain-Uhlenbeck process with persistence parameter γ and standard deviation ξ. The realization of x takes place on a discrete grid

$$x \in \{-n\Delta. -(n-1)\Delta, ..., 0, ..., (n-1)\Delta, n\Delta\},$$

where $\Delta > 0$ is the step size and $n \geq 1$ is an integer number to ensure that the number of grid points is at least 3. When a Poisson shock λ hits the economy, x changes to a new level x' by one grid point where

$$x' = \begin{cases} x + \Delta & \text{with probability } \frac{1}{2}\left(1 - \frac{x}{n\Delta}\right), \\ x - \Delta & \text{with probability } \frac{1}{2}\left(1 + \frac{x}{n\Delta}\right). \end{cases}$$

That means the chance of moving down to a bad state is higher than the chance of moving up to a good state. To complete the process' characteristics, define $\gamma = \lambda/n$ and $\xi = \sqrt{\lambda}\Delta$. These two parameters also characterize the behavior of y and setting $\gamma = 0.004$ and $\xi = 0.025$ will pin down the autocorrelation and standard deviation of y.

We solve the system of equations (1.19) and (1.20) recursively and obtain a vector of θ. We then simulate the model by starting with an initial θ in a given aggregate state and compute the initial unemployment rate given by the Beveridge curve (1.14). In the following step, 1212 levels of unemployment rate are randomly generated and the first 1000 observations are discarded to eliminate any initial effect. The sample remains at 212 observations, corresponding to the number of quarters from 1951 to 2003. We log the data generated by the model and and detrend it, using an HP filter with a smoothing parameter of 10^5. This procedure is then repeated 10,000 times.

APPENDIX B

PROOFS IN CHAPTER III

B.1 Probability of rejecting job offer

The probability of rejecting a job offer initiated by workers is thus the separation triangle shown in Figure 3.1 and is defined by

$$\begin{aligned} Q &= \int_{\underline{\epsilon}}^{\hat{\epsilon}} G[\hat{\epsilon} - \epsilon + \underline{\nu}] dF(\epsilon), \\ &= \phi \int_{\underline{\epsilon}}^{\hat{\epsilon}} \left[1 - e^{-\gamma(\hat{\epsilon}-\epsilon)}\right] e^{-\phi((\hat{\epsilon}-\epsilon))} d\epsilon \\ &= 1 - \frac{\gamma}{\gamma - \phi} e^{-\phi(\hat{\epsilon}-\underline{\epsilon})} + \frac{\phi}{\gamma - \phi} e^{-\gamma(\hat{\epsilon}-\underline{\epsilon})}. \end{aligned}$$

Similarly, the probability of rejecting a job offer initiated by firms is

$$L = 1 - \frac{\gamma}{\gamma - \phi} e^{-\phi(\hat{\nu}-\underline{\nu})} + \frac{\phi}{\gamma - \phi} e^{-\gamma(\hat{\nu}-\underline{\nu})}.$$

B.2 Ex-ante expected surplus

By definition, the firm's ex-ante expected surplus is equivalent to

$$\begin{aligned} EP^{\text{firm}} &= \beta E\left(P^{\text{firm}}|\text{firm offer}\right) + (1-\beta)E\left(P^{\text{firm}}|\text{worker offer}\right) \\ &= \beta \iint_{\text{firm offer}} J(\epsilon)dF(\epsilon)dG(\nu) + (1-\beta)\iint_{\text{worker offer}} J(\epsilon)dF(\epsilon)dG(\nu) \end{aligned} \tag{B.1}$$

We need to compute $J(\epsilon)$ in the firm offer and worker offer cases, while accounting for the interior and the corner solution in each party offer. When firms make wage offers, the interior solution implies that

$$J(\epsilon) = \frac{1}{r+\lambda}\frac{1}{\gamma}$$

and the corner solution implies that

$$J(\epsilon) = \frac{1}{r+\lambda}(\epsilon - \hat{\epsilon} + \frac{1}{\gamma})$$

When workers make wage offers, the interior and corner solutions are equivalent to

$$J(\epsilon) = \begin{cases} \frac{1}{r+\lambda}(\nu - \hat{\nu} + \epsilon + \frac{1}{\phi}) & \text{if } \nu < \hat{\nu} \\ \frac{1}{r+\lambda}(\epsilon + \frac{1}{\phi}) & \text{otherwise} \end{cases}$$

Hence

$$\begin{aligned} EP^{\text{firm}} &= \beta \times \left[\int_{\underline{\epsilon}}^{\hat{\epsilon}} \int_{\hat{\epsilon}-\epsilon+\underline{\nu}}^{+\infty} \frac{1}{\gamma} dFdG + \int_{\hat{\epsilon}}^{+\infty}\int_{\underline{\nu}}^{+\infty} \left(\epsilon - \hat{\epsilon} + \frac{1}{\gamma}\right) dFdG\right] + (1-\beta) \times \\ &\quad \times \left[\int_{\underline{\nu}}^{\hat{\nu}} \int_{\hat{\nu}-\nu+\underline{\epsilon}}^{+\infty} \left(\nu - \hat{\nu} + \epsilon + \frac{1}{\phi}\right) dFdG + \int_{\hat{\nu}_s}^{+\infty}\int_{\underline{\epsilon}}^{+\infty} \left(\epsilon + \frac{1}{\phi}\right) dFdG\right] \\ &= \frac{1}{r+\lambda}\left[\frac{\beta}{\gamma}(1-Q) + \frac{\beta}{\phi}e^{-\phi(\hat{\epsilon}-\underline{\epsilon})} + \frac{1-\beta}{\phi}(1-L)\right] \end{aligned}$$

By applying the same process, we can compute the worker's ex-ante expected surplus as

$$EP^{\text{worker}} = \frac{1}{r+\lambda}\left[\frac{\beta}{\gamma}(1-Q) + \frac{1-\beta}{\gamma}e^{-\gamma(\hat{\nu}-\underline{\nu})} + \frac{1-\beta}{\phi}(1-L)\right] + U.$$

Bibliography

Abowd, J. M., F. Kramarz, and D. N. Margolis (1998). High wage workers and high wage firms. *Working paper*.

Afridi, F., S. Xin Li, and Y. Ren (2009). Social identity and inequality: The impact of China's hukou system. *Working paper*.

Albrecht, J., L. Navarro, and V. Vroman (2009). The effects of labor market policies in an economy with an informal sector. *The Economic Journal July*(119), 1105–1129.

Appleton, S., J. Knight, L. Song, and Q. Xia (2002). Labor retrenchment in China: determinants and consequences. *China Economic Review 13*, 252–275.

Blanchfower, D., A. Oswald, and P. Sanfey (1996). Wages, profits, and rent-sharing. *Quarterly Journal of Economics* (111), 227–251.

Boeri, T. and P. Garibaldi (2005). Shadow sorting. *NBER International Seminar on Macroeconomics*, 125–170.

Bosch, M. and J. Esteban-Pretel (2009). Cyclical informality and unemployment. *Working paper*.

Brügemann, B. and G. Moscarini (2008). Rent rigidity, asymmetric information, and volatility bounds in labor markets. *Working paper*.

Burdett, K. and K. Judd (1983). Equilibirum price dispersion. *Econometrica 51*, 955–970.

Burdett, K. and D. T. Mortensen (1998). Wage differentials, employer size, and unemployment. *International Economic Review 39*(2), 257–273.

Cahuc, P., F. Marque, and E. Wasmer (2000). Intrafirm wage bargaining in matching models: macroeconomic implications and resolution methods with multiple labor inputs. *International Economic Review 49*(3), 943–972.

Cahuc, P., F. Postel-Vinay, and J.-M. Robin (2006). Wage bargaining with on-thejob search: theory and evidence. *Econometrica 74*(2), 323–364.

Cahuc, P. and E. Wasmer (2001). Does intrafrim bargaining matter in the large firm's matching model? *Macroeconomic Dynamics*, 742–747.

Campbell, J. R. (1998). Entry, exit, embodied technology, and business cycles. *Review of Economic Dynamics* (1), 371–408.

Christensen, B. J., R. Lentz, D. T. Mortensen, G. R. Neumann, and A. Wervatz (2005). On the job search and the wage distribution. *Journal of Labor Economics 23*(1), 31–58.

Costain, J. S. and M. Reiter (2007). Business cycles, unemployment insurance, and the calibration of matching models. *Journal of Economic Dynamics and Control 32*(4), 1120–55.

Cowell, F. (2000). Measurement of inequality. *Handbook of Income Distribution*, 87–166.

Delacroix, A. (2006). A multisectorial matching model of unions. *Journal of Monetary Economics* (53), 573–596.

Delacroix, A. and E. Wasmer (2006). Job and workers flows in europe and the US: Specific skills or employment protection. *Working paper*.

Djankov, S., R. La Porta, F. Lopez-de Silanes, and A. Shleifer (2002). The regulation of entry. *Quarterly Journal of Economics* (117), 1–37.

Ebell, M. and C. Haefke (2009). Product market deregulation and the us employment miracle. *Review of Economics Dynamics 12*(3), 497–504.

Eckstein, Z. and E. Nagypal (2004). The evolution of U.S. earnings inequality: 1961-2002. *Federal Reserve Bank of Minneapolis Quarterly Review 28*(2), 10–29.

Elsby, M. and R. Michaels (2008). Marginal jobs, heterogeneous firms and unemployment flows. *Working paper*.

Fallick, B. and C. Fleischman (2004). Employer-to-employer flows in the U.S. labor market: The complete picture of gross worker flows. *Working paper*.

Fan, S. and P. G. Pardey (1997). Research, productivity, and output growth in Chinese agriculture. *Journal of Development Economics 53*, 115–137.

Guerrieri, V. (2007). Heterogeneity, job creation and unemployment volatility. *Scandinavian Journal of Economics 109*(4), 667–693.

Guo, F. and R. Iredale (2004). The impact of hukou status on migrants' employment: Findings from the 1997 Beijing Migrant Census. *Internationa Migration Review 38*(2), 709–73.

Gutierrz, C., P. Paci, and B. Park (2009). Quantifying the impact of financial crisis on a multi-sector labor market. *Working paper*.

Hagedorn, M. and I. Manovskii (2008). The cyclical behavior of equilibrium unemployment and vacancies revisited. *American Economic Review 98*(4), 1692–1706.

Hall, R. (2005). Employment fluctuations with equilibrium wage stickiness. *American Economic Review 95*(1), 53–69.

Hildreth, A. and A. Oswald (1997). Rent-sharing and wages: evidence from company and establishment panels. *Journal of Labor Economics* (15), 318–337.

Hornstein, A., P. Krusell, and G. Violante (2007). Frictional wage dispersion in search models: A quantitative assessment. *American Economics Review, forthcoming*.

Hosios, A. J. (1990). On the efficiency of matching and related models of search and unemployment. *Review of Economic Studies* (57), 279–298.

Huang, Y. (2010). Urbanisation, hukou system and government land ownership: effects on rural migrant workers and on rural and urban hukou residents. *Working paper* (OECD Development Center).

Knight, J. and L. Yueh (2004). Job mobility of residents and migrants in urban China. *Journal of Comparative Economics 32*, 637–660.

Laing, D., C. Park, and P. Wang (2005). A modified Harris-Todaro model for rural-urban migration for China. *in F. Kwan and E. Yu, eds., Critical Issues in China's Growth and Development Ashgate Publishing Limited*, 245–64.

Lee, V. (2000). Unemployment insurance and assistance systems in mainland China. (Research and Library Services Division Legislative Council Secretariat).

Liu, Z. (2005). Institution and inequality: the hukou system in China. *Journal of Comparative Economics 33*(1), 133–157.

Martins, J., S. Scapetta, and D. Pilat (1996). Markup pricing, market structure and the business cycle. *OECD Economic Studies 27*, 71–105.

Mortensen, D. (2003). *Wage Dispersion: Why Are Similar Workers Paid Differently?* Cambridge and London: MIT Press.

Mortensen, D. and E. Nagypal (2007). More on unemployment and vacancy fluctuations. *Review of Economic Dynamics 10*, 327–347.

Mortensen, D. and C. Pissarides (1994). Job creation and job destruction in the theory of unemployment. *Review of Economic Studies 61*, 397–415.

Papp, T. (2009). Explaining frictional wage dispersion. *Working paper*.

Petrongolo, B. and C. Pissarides (2001). Looking into the black box: A survey of the matching function. *Journal of Economic Literature 39*, 390–431.

Pissarides, C. (1985). Short-run equilibrium dynamics of unemployment vacancies, and real wages. *American Economics Review 75*(4), 676–90.

Pissarides, C. (2000). *Equilibrium unemployment theory*. Cambridge and London: MIT Press.

Pissarides, C. (2009). The unemployment volatility puzzle: Is wage stickiness the answer? *Econometrica 77*(5), 1339–1369.

Postel-Vinay, F. and J.-M. Robin (2002). Equilibrium wage dispersion with worker and employer heterogeneity. *Econometrica 70*(6), 2295–2350.

Rickne, J. (2010). Protecting workers in the workers' state: Labor market tightness and unemployment insurance in Chinese industrial firms. *Working paper*.

Satchi, M. and J. Temple (2006). Growth and labour markets in developing countries. *CEPR Discussion Paper No* (5515).

Shimer, R. (2004). The consequences of rigid wages in search models. *Journal of the European Economic Association Papers and Proceedings 2*(2), 469–479.

Shimer, R. (2005a). The cyclical behavior of equilibrium unemployment and vacancies. *American Economic Review 95*(1), 25–49.

Shimer, R. (2005b). Reassessing the ins and outs of unemployment. *Unpublished Paper University of Chicago.*

Silva, J. and M. Toledo (2008). Labor turnover costs and the behavior of vacancies and unemployment. *Macroeconomic Dynamics*, Forthcoming.

Stole, L. A. and J. Zwiebel (1996). Intra-firm bargaining under non-binding contracts. *Review of Economic Studies* (63), 375–410.

Torado, M. (1969). A model of labor migration and urban unemployment in less developed countries. *American Economic Review 60*, 138–148.

Torado, M. and J. Harris (1970). Migration, unemployment, and development: a two-sector analysis. *American Economic Review 61*, 126–141.

Whalley, J. and S. Zhang (2007). A numerical simulation analysis of (Hukou) labour mobility restrictions in China. *Journal of Development Economics 83*, 392–410.

Xing, C. (2009). Migration, self-selection, and income distributions: Evidence from rural and urban China.

Zenou, Y. (2008). Job search and mobility in developing countries: theory and policy implications. *Journal of Development Economics 86*(2), 336–355.

Zhao, Z. (2003). Migration, labor market flexibility, and wage determination in China – a review. *China Center for Economic Research Peking University*, 252–275.